
HONI SOIT QUI MAL Y PENSE
DIEU ET MON DROIT

REPORT

OF THE

EIGHTY-FIRST MEETING OF THE

BRITISH ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE

PORTSMOUTH: 1911

AUGUST 30–SEPTEMBER 6

LONDON
JOHN MURRAY, ALBEMARLE STREET
1912

Office of the Association: Burlington House, London, W.

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OFFICERS AND COUNCIL, 1911-1912.

PATRON

HIS MAJESTY THE KING

PRESIDENT.

Professor Sir WILLIAM RAMSAY, K.C.B., Ph.D., LL.D., D.Sc., M.D., F.R.S.

VICE-PRESIDENTS.

H.R.H. The Princess Henry of Battenberg.
Alderman Sir T. Scott Foster, J.P., Mayor of Portsmouth.
His Grace the Lord Archbishop of Canterbury, G.C.V.O., D.D.
His Grace the Lord Archbishop of York, D.D.
The Most Hon. the Marquess of Winchester, Lord Lieutenant of the County of Hants.
Field Marshal the Right Hon. the Earl Roberts, K.G., K.P., G.C.B., O.M., V.C.
The Right Rev. the Lord Bishop of Winchester, D.D.
The Right Hon. Lord Macnaghten, G.C.B., G.C.M.G.
Admiral Sir A. W. Moore, G.C.B., K.C.V.O., C.M.G.
Major-General J. K. Trotter, C.B., C.M.G.
Rear-Admiral A. G. Tate, R.N.
Colonel Sir W. T. Dupree, D.L., V.D., J.P.
A. G. Vernon Harcourt, M.A., D.C.L., F.R.S.

PRESIDENT ELECT.

Professor E. A. Schafer, LL.D., D.Sc., M.D., F.R.S.

VICE-PRESIDENTS ELECT

The Right Hon. the Earl of Strathmore, Lord Lieutenant of the County of Forfar.
James Ferguson, K.C., Sheriff of Forfarshire.
The Hon. the Lord Provost of Dundee, James Urquhart, LL.D.
The Right Hon. the Earl of Camperdown.
The Right Hon. Lord Kinnaird.
The Right Rev. Bishop Robberds, D.D., Bishop of Brechin, Primus of the Episcopal Church of Scotland.
The Right Rev. Angus Macfarlane, D.D., Bishop of Dunkeld.
Sir James Donaldson, LL.D., Principal of the University of St. Andrews.
J. Yule Mackay, M.D., LL.D., Principal of University College, Dundee.
Sir William Ogilvy Dalgleish, Bart., of Errol Park.
Sir George Baxter, LL.D.
J. K. Caird, LL.D.
The President of the Chamber of Commerce, Dundee (1912).
The Moderator of the Church of Scotland (1912).
The Moderator of the United Free Church of Scotland (1912).

GENERAL TREASURER.

Professor John Perry, D.Sc., LL.D., F.R.S.

GENERAL SECRETARIES.

Major P. A. MacMahon, R.A., D.Sc., F.R.S. | Professor W. A. Herdman, D.Sc., F.R.S.

ASSISTANT SECRETARY.

O. J. R. Howarth, M.A., Burlington House, London, W.

CHIEF CLERK AND ASSISTANT TREASURER.

H. C. Stewardson, Burlington House, London, W.

LOCAL TREASURER FOR THE MEETING AT DUNDEE.

W. G. Leggatt.

LOCAL SECRETARIES FOR THE MEETING AT DUNDEE.

W. H. Blyth Martin. | Dr. A. H. Millar. | Prof. D'Arcy Thompson, C.B.

[P.T.O.

ORDINARY MEMBERS OF THE COUNCIL.

Abney, Sir W., K.C.B., F.R.S.
Anderson, Tempest, M.D., D.Sc.
Armstrong, Professor H. E., F.R.S.
Brabrook, Sir Edward, C.B.
Brunton, Sir Lauder, Bart., F.R.S.
Close, Colonel C. F., R.E., C.M.G.
Craigie, Major P. G., C.B.
Crooke, W., B.A.
Griffiths, Principal E. H., F.R.S.
Haddon, Dr. A. C., F.R.S.
Hall, A. D., F.R.S.
Halliburton, Professor W. D., F.R.S.
Hartland, E. Sidney, F.S.A.
Marr, Dr. J. E., F.R.S.
Meldola, Professor R., F.R.S.
Mitchell, Dr. P. Chalmers, F.R.S.
Myres, Professor J. L., M.A.
Poulton, Professor E. B., F.R.S.
Prain, Lieut.-Colonel D., C.I.E., F.R.S.
Sherrington, Professor C. S., F.R.S.
Teall, J. J. H., F.R.S.
Thompson, Dr. Silvanus P., F.R.S.
Trouton, Professor F. T., F.R.S.
Tutton, Dr. A. E. H., F.R.S.
White, Sir W. H., K.C.B., F.R.S.

EX-OFFICIO MEMBERS OF THE COUNCIL.

The Trustees, past Presidents of the Association, the President and Vice-Presidents for the year, the President and Vice-Presidents Elect, past and present General Treasurers and General Secretaries, past Assistant General Secretaries, and the Local Treasurers and Local Secretaries for the ensuing Annual Meeting.

TRUSTEES (PERMANENT).

The Right Hon. Lord Avebury, D.C.L., LL.D., F.R.S., F.L.S.
The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., F.R.S., F.R.A.S.
Sir Arthur W. Rücker, M.A., D.Sc., LL.D., F.R.S.

PAST PRESIDENTS OF THE ASSOCIATION.

Lord Avebury, D.C.L., F.R.S.
Lord Rayleigh, D.C.L., F.R.S.
Sir H. E. Roscoe, D.C.L., F.R.S.
Sir A. Geikie, K.C.B., Pres. R.S.
Lord Lister, D.C.L., F.R.S.
Sir William Crookes, O.M., F.R.S.
Sir W. Turner, K.C.B., F.R.S.
Sir A. W. Rücker, D.Sc., F.R.S.
Sir James Dewar, LL.D., F.R.S.
Sir Norman Lockyer, K.C.B., F.R.S.
Arthur J. Balfour, D.C.L., F.R.S.
Sir George Darwin, K.C.B., F.R.S.
Sir E. Ray Lankester, K.C.B., F.R.S.
Sir David Gill, K.C.B., F.R.S.
Dr. Francis Darwin, F.R.S.
Sir J. J. Thomson, F.R.S.
Prof. T. G. Bonney, Sc.D., F.R.S.

PAST GENERAL OFFICERS OF THE ASSOCIATION.

P. L. Sclater, Ph.D., F.R.S.
Prof. T. G. Bonney, Sc.D., F.R.S.
A. Vernon Harcourt, F.R.S.
Sir A. W. Rücker, D.Sc., F.R.S.
Prof. E. A. Schäfer, F.R.S.
Dr. D. H. Scott, M.A., F.R.S.
Dr. G. Carey Foster, F.R.S.
Dr. J. G. Garson.

AUDITORS.

Sir Edward Brabrook, C.B.
Professor H. McLeod, F.R.S.

RULES OF THE BRITISH ASSOCIATION.

[*Adopted by the General Committee at Leicester*, 1907, *with subsequent amendments.*]

CHAPTER I.

Objects and Constitution.

Objects.

1. The objects of the British Association for the Advancement of Science are: To give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of those who cultivate Science in different parts of the British Empire with one another and with foreign philosophers; to obtain more general attention for the objects of Science and the removal of any disadvantages of a public kind which impede its progress.

The Association contemplates no invasion of the ground occupied by other Institutions.

Constitution.

2. The Association shall consist of Members, Associates, and Honorary Corresponding Members.

The governing body of the Association shall be a General Committee, constituted as hereinafter set forth; and its affairs shall be directed by a Council and conducted by General Officers appointed by that Committee.

Annual Meetings.

3. The Association shall meet annually, for one week or longer, and at such other times as the General Committee may appoint. The place of each Annual Meeting shall be determined by the General Committee not less than two years in advance; and the arrangements for these meetings shall be entrusted to the Officers of the Association.

CHAPTER II.

The General Committee.

Constitution.

1. The General Committee shall be constituted of the following persons:—

(i) *Permanent Members*—

(*a*) **Past and present Members of the Council, and past and present Presidents of the Sections.**

CHAPTER IV.

Research Committees.

Procedure.

1. Every proposal for special research, or for a grant of money in aid of special research, which is made in any Section, shall be considered by the Committee of that Section; and, if such proposal be approved, it shall be referred to the Committee of Recommendations.

Constitution.

In consequence of any such proposal, a Sectional Committee may recommend the appointment of a Research Committee, composed of Members of the Association, to conduct research or administer a grant in aid of research, and in any case to report thereon to the Association; and the Committee of Recommendations may include such recommendation in their report to the General Committee.

2. Every appointment of a Research Committee shall be proposed at a meeting of the Sectional Committee and adopted at a subsequent meeting. The Sectional Committee shall settle the terms of reference and suitable Members to serve on it, which must be as small as is consistent with its efficient working; and shall nominate a Chairman and a Secretary. Such Research Committee, if appointed, shall have power to add to their numbers.

Proposals by Sectional Committees.

3. The Sectional Committee shall state in their recommendation whether a grant of money be desired for the purposes of any Research Committee, and shall estimate the amount required.

All proposals sanctioned by a Sectional Committee shall be forwarded by the Recorder to the Assistant Secretary not later than noon on the Monday of the Annual Meeting for presentation to the Committee of Recommendations.

Tenure.

4. Research Committees are appointed for one year only. If the work of a Research Committee cannot be completed in that year, application may be made through a Sectional Committee at the next Annual Meeting for reappointment, with or without a grant—or a further grant—of money.

Reports.

5. Every Research Committee shall present a Report, whether interim or final, at the Annual Meeting next after that at which it was appointed or reappointed. Interim Reports, whether intended for publication or not, must be submitted in writing. Each Sectional Committee shall ascertain whether a Report has been made by each Research Committee

appointed on their recommendation, and shall report to the Committee of Recommendations on or before the Monday of the Annual Meeting.

GRANTS. (*a*) Drawn by Chairman.

6. In each Research Committee to which a grant of money has been made, the Chairman is the only person entitled to call on the General Treasurer for such portion of the sum granted as from time to time may be required.

(*b*) Expire on June 30.

Grants of money sanctioned at the Annual Meeting expire on June 30 following. The General Treasurer is not authorised, after that date, to allow any claims on account of such grants.

(*c*) Accounts and balance in hand.

The Chairman of a Research Committee must, before the Annual Meeting next following the appointment of the Research Committee, forward to the General Treasurer a statement of the sums that have been received and expended, together with vouchers. The Chairman must then either return the balance of the grant, if any, which remains unexpended, or, if further expenditure be contemplated, apply for leave to retain the balance.

(*d*) Additional Grant

When application is made for a Committee to be reappointed, and to retain the balance of a former grant, and also to receive a further grant, the amount of such further grant is to be estimated as being sufficient, together with the balance proposed to be retained, to make up the amount desired.

(*e*) *Caveat*

In making grants of money to Research Committees, the Association does not contemplate the payment of personal expenses to the Members.

A Research Committee, whether or not in receipt of a grant, shall not raise money, in the name or under the auspices of the Association, without special permission from the General Committee.

Disposal of specimens, apparatus, &c.

7. Members and Committees entrusted with sums of money for collecting specimens of any description shall include in their Reports particulars thereof, and shall reserve the specimens thus obtained for disposal, as the Council may direct.

Committees are required to furnish a list of any apparatus which may have been purchased out of a grant made by the Association, and to state whether the apparatus is likely to be useful for continuing the research in question or for other specific purposes.

All instruments, drawings, papers, and other property of the Association, when not in actual use by a Committee, shall be deposited at the Office of the Association.

CHAPTER V.

The Council.

Constitution. 1. The Council shall consist of *ex officio* Members and of Ordinary Members elected annually by the General Committee.

(i) The *ex officio* Members are—the Trustees, past Presidents of the Association, the President and Vice-Presidents for the year, the President and Vice-Presidents Elect, past and present General Treasurers and General Secretaries, past Assistant General Secretaries, and the Local Treasurers and Local Secretaries for the ensuing Annual Meeting.

(ii) The Ordinary Members shall not exceed twenty-five in number. Of these, not more than twenty shall have served on the Council as Ordinary Members in the previous year.

Functions 2. The Council shall have authority to act, in the name and on behalf of the Association, in all matters which do not conflict with the functions of the General Committee.

In the interval between two Annual Meetings, the Council shall manage the affairs of the Association and may fill up vacancies among the General and other Officers, until the next Annual Meeting.

The Council shall hold such meetings as they may think fit, and shall in any case meet on the first day of the Annual Meeting, in order to complete and adopt the Annual Report, and to consider other matters to be brought before the General Committee.

The Council shall nominate for election by the General Committee, at each Annual Meeting, a President and General Officers of the Association.

Suggestions for the Presidency shall be considered by the Council at the Meeting in February, and the names selected shall be issued with the summonses to the Council Meeting in March, when the nomination shall be made from the names on the list.

The Council shall have power to appoint and dismiss such paid officers as may be necessary to carry on the work of the Association, on such terms as they may from time to time determine.

3. Election to the Council shall take place at the same time as that of the Officers of the Association. **Elections.**

(i) At each Annual Election, the following Ordinary Members of the Council shall be ineligible for re-election in the ensuing year:

(*a*) Three of the Members who have served for the longest consecutive period, and

(*b*) Two of the Members who, being resident in or near London, have attended the least number of meetings during the past year.

Nevertheless, it shall be competent for the Council, by an unanimous vote, to reverse the proportion in the order of retirement above set forth.

(ii) The Council shall submit to the General Committee, in their Annual Report, the names of twenty-three Members of the Association whom they recommend for election as Members of Council.

(iii) Two Members shall be elected by the General Committee, without nomination by the Council; and this election shall be at the same meeting as that at which the election of the other Members of the Council takes place.

Any member of the General Committee may propose another member thereof for election as one of these two members of Council, and, if only two are so proposed, they shall be declared elected; but, if more than two are so proposed, the election shall be by show of hands, unless five members at least require it to be by ballot.

CHAPTER VI.

The President, General Officers, and Staff.

1. The President assumes office on the first day of the Annual Meeting, when he delivers a Presidential Address. He resigns office at the next Annual Meeting, when he inducts his successor into the Chair. **The President.**

The President shall preside at all meetings of the Association or of its Council and Committees which he attends in his capacity as President. In his absence, he shall be represented by a Vice-President or past President of the Association.

2. The General Officers of the Association are the General Treasurer and the General Secretaries. **General Officers.**

It shall be competent for the General Officers to act, in the name of the Association, in any matter of urgency which cannot be brought under the consideration of the Council; and they shall report such action to the Council at the next meeting.

The General Treasurer.

3. The General Treasurer shall be responsible to the General Committee and the Council for the financial affairs of the Association.

The General Secretaries.

4. The General Secretaries shall control the general organisation and administration, and shall be responsible to the General Committee and the Council for conducting the correspondence and for the general routine of the work of the Association, excepting that which relates to Finance.

The Assistant Secretary.

5. The Assistant Secretary shall hold office during the pleasure of the Council. He shall act under the direction of the General Secretaries, and in their absence shall represent them. He shall also act on the directions which may be given him by the General Treasurer in that part of his duties which relates to the finances of the Association.

The Assistant Secretary shall be charged, subject as aforesaid: (i) with the general organising and editorial work, and with the administrative business of the Association; (ii) with the control and direction of the Office and of all persons therein employed; and (iii) with the execution of Standing Orders or of the directions given him by the General Officers and Council. He shall act as Secretary, and take Minutes, at the meetings of the Council, and at all meetings of Committees of the Council, of the Committee of Recommendations, and of the General Committee.

Assistant Treasurer.

6. The General Treasurer may depute one of the Staff, as Assistant Treasurer, to carry on, under his direction, the routine work of the duties of his office.

The Assistant Treasurer shall be charged with the issue of Membership Tickets, the payment of Grants, and such other work as may be delegated to him.

CHAPTER VII.

Finance.

Financial Statements.

1. The General Treasurer, or Assistant Treasurer, shall receive and acknowledge all sums of money paid to the Association. He shall submit, at each meeting of the Council, an *interim* statement of his Account; and, after

June 30 in each year, he shall prepare and submit to the General Committee a balance-sheet of the Funds of the Association.

2. The Accounts of the Association shall be audited, annually, by Auditors appointed by the General Committee. Audit.

3. The General Treasurer shall make all ordinary payments authorised by the General Committee or by the Council. Expenditure.

4. The General Treasurer is empowered to draw on the account of the Association, and to invest on its behalf, part or all of the balance standing at any time to the credit of the Association in the books of the Bank of England, either in Exchequer Bills or in any other temporary investment, and to change, sell, or otherwise deal with such temporary investment as may seem to him desirable. Investments.

5. In the event of the General Treasurer being unable, from illness or any other cause, to exercise the functions of his office, the President of the Association for the time being and one of the General Secretaries shall be jointly empowered to sign cheques on behalf of the Association. Cheques.

CHAPTER VIII.

The Annual Meetings.

1. Local Committees shall be formed to assist the General Officers in making arrangements for the Annual Meeting, and shall have power to add to their number. Local Officers and Committees.

2. The General Committee shall appoint, on the recommendation of the Local Reception or Executive Committee for the ensuing Annual Meeting, a Local Treasurer or Treasurers and two or more Local Secretaries, who shall rank as officers of the Association, and shall consult with the General Officers and the Assistant Secretary as to the local arrangements necessary for the conduct of the meeting. The Local Treasurers shall be empowered to enrol Members and Associates, and to receive subscriptions.

3. The Local Committees and Sub-Committees shall undertake the local organisation, and shall have power to act in the name of the Association in all matters pertaining to the local arrangements for the Annual Meeting other than the work of the Sections. Functions.

CHAPTER IX.

The Work of the Sections.

THE SECTIONS.

1. The scientific work of the Association shall be transacted under such Sections as shall be constituted from time to time by the General Committee.

It shall be competent for any Section, if authorised by the Council for the time being, to form a Sub-Section for the purpose of dealing separately with any group of communications addressed to that Section.

Sectional Officers.

2. There shall be in each Section a President, two or more Vice-Presidents, and two or more Secretaries They shall be appointed by the Council, for each Annual Meeting in advance, and shall act as the Officers of the Section from the date of their appointment until the appointment of their successors in office for the ensuing Annual Meeting.

Of the Secretaries, one shall act as Recorder of the Section, and one shall be resident in the locality where the Annual Meeting is held.

Rooms

3. The Section Rooms and the approaches thereto shall not be used for any notices, exhibitions, or other purposes than those of the Association.

SECTIONAL COMMITTEES.

4. The work of each Section shall be conducted by a Sectional Committee, which shall consist of the following :—

Constitution.

(i) The Officers of the Section during their term of office.
(ii) All past Presidents of that Section.
(iii) Such other Members of the Association, present at any Annual Meeting, as the Sectional Committee, thus constituted, may co-opt for the period of the meeting :

Provided always that—

Privilege of Old Members.

(*a*) Any Member of the Association who has served on the Committee of any Section in any previous year, and who has intimated his intention of being present at the Annual Meeting, is eligible as a member of that Committee at their first meeting.

Daily Co-optation.

(*b*) A Sectional Committee may co-opt members, as above set forth, at any time during the Annual Meeting, and shall publish daily a revised list of the members.

(c) A Sectional Committee may, at any time during the Annual Meeting, appoint not more than three persons present at the meeting to be Vice-Presidents of the Section, in addition to those previously appointed by the Council. Additional Vice-Presidents.

5. The chief executive officers of a Section shall be the President and the Recorder. They shall have power to act on behalf of the Section in any matter of urgency which cannot be brought before the consideration of the Sectional Committee; and they shall report such action to the Sectional Committee at its next meeting. EXECUTIVE FUNCTIONS

The President (or, in his absence, one of the Vice-Presidents) shall preside at all meetings of the Sectional Committee or of the Section. His ruling shall be absolute on all points of order that may arise. Of President

The Recorder shall be responsible for the punctual transmission to the Assistant Secretary of the daily programme of his Section, of the recommendations adopted by the Sectional Committee, of the printed returns, abstracts, reports, or papers appertaining to the proceedings of his Section at the Annual Meeting, and for the correspondence and minutes of the Sectional Committee. And of Recorder.

6. The Sectional Committee shall nominate, before the close of the Annual Meeting, not more than six of its own members to be members of an Organising Committee, with the officers to be subsequently appointed by the Council, and past Presidents of the Section, from the close of the Annual Meeting until the conclusion of its meeting on the first day of the ensuing Annual Meeting. Organising Committee.

Each Organising Committee shall hold such Meetings as are deemed necessary by its President for the organisation of the ensuing Sectional proceedings, and shall hold a meeting on the first Wednesday of the Annual Meeting: to nominate members of the Sectional Committee, to confirm the Provisional Programme of the Section, and to report to the Sectional Committee.

Each Sectional Committee shall meet daily, unless otherwise determined, during the Annual Meeting: to co-opt members, to complete the arrangements for the next day, and to take into consideration any suggestion for the advancement of Science that may be offered by a member, or may arise out of the proceedings of the Section. Sectional Committee.

No paper shall be read in any Section until it has been accepted by the Sectional Committee and entered as accepted on its Minutes. Papers and Reports.

Associates shall not receive the Annual Report gratuitously. They shall not be eligible to serve on any Committee, nor be qualified to hold any office in the Association.

(iv) *Ladies* may become Members or Associates on the same terms as gentlemen, or can obtain a *Lady's Ticket* (transferable to ladies only) on the payment of One Pound.

Corresponding Members.

3. Corresponding Members may be appointed by the General Committee, on the nomination of the Council. They shall be entitled to all the privileges of Membership.

Annual Subscriptions.

4. Subscriptions are payable at or before the Annual Meeting. Annual Members not attending the meeting may make payment at any time before the close of the financial year on June 30 of the following year.

The Annual Report.

5. The Annual Report of the Association shall be forwarded *gratis* to individuals and institutions entitled to receive it.

Annual Members whose subscriptions have been intermitted shall be entitled to purchase the Annual Report at two-thirds of the publication price; and Associates for a year shall be entitled to purchase, at the same price, the volume for that year.

Volumes not claimed within two years of the date of publication can only be issued by direction of the Council.

CHAPTER XI.

Corresponding Societies: Conference of Delegates.

Corresponding Societies are constituted as follows:

AFFILIATED SOCIETIES.

1. (i) Any Society which undertakes local scientific investigation and publishes the results may become a Society *affiliated* to the British Association.

Each Affiliated Society may appoint a Delegate, who must be or become a Member of the Association and must attend the meetings of the Conference of Delegates. He shall be *ex officio* a Member of the General Committee.

ASSOCIATED SOCIETIES.

(ii) Any Society formed for the purpose of encouraging the study of Science, which has existed for three years and numbers not fewer than fifty members, may become a Society *associated* with the British Association.

Each Associated Society shall have the right to appoint a Delegate to attend the Annual Conference. Such Delegates must be or become either Members or Associates of the British Association, and shall have all the rights of Delegates appointed by the Affiliated Societies, except that of membership of the General Committee.

Applications.

2. Application may be made by any Society to be placed on the list of Corresponding Societies. Such application must be addressed to the Assistant Secretary on or before the 1st of June preceding the Annual Meeting at which it is intended it should be considered, and must, in the case of Societies desiring to be affiliated, be accompanied by specimens of the publications of the results of local scientific investigations recently undertaken by the Society.

CORRESPONDING SOCIETIES COMMITTEE.

3. A Corresponding Societies Committee shall be annually nominated by the Council and appointed by the General Committee, for the purpose of keeping themselves generally informed of the work of the Corresponding Societies and of superintending the preparation of a list of the papers published by the Affiliated Societies. This Committee shall make an Annual Report to the Council, and shall suggest such additions or changes in the list of Corresponding Societies as they may consider desirable.

Procedure.

(i) Each Corresponding Society shall forward every year to the Assistant Secretary of the Association, on or before June 1, such particulars in regard to the Society as may be required for the information of the Corresponding Societies Committee.

(ii) There shall be inserted in the Annual Report of the Association a list of the papers published by the Corresponding Societies during the preceding twelve months which contain the results of local scientific work conducted by them—those papers only being included which refer to subjects coming under the cognisance of one or other of the several Sections of the Association.

CONFERENCE OF DELEGATES.

4. The Delegates of Corresponding Societies shall constitute a Conference, of which the Chairman, Vice-Chairman, and Secretary or Secretaries shall be nominated annually by the Council and appointed by the General Committee. The members of the Corresponding Societies Committee shall be *ex officio* members of the Conference.

Procedure and Functions.

(i) The Conference of Delegates shall be summoned by the Secretaries to hold one or more meetings during

each Annual Meeting of the Association, and shall be empowered to invite any Member or Associate to take part in the discussions.

(ii) The Conference of Delegates shall be empowered to submit Resolutions to the Committee of Recommendations for their consideration, and for report to the General Committee.

(iii) The Sectional Committees of the Association shall be requested to transmit to the Secretaries of the Conference of Delegates copies of any recommendations to be made to the General Committee bearing on matters in which the co-operation of Corresponding Societies is desirable. It shall be competent for the Secretaries of the Conference of Delegates to invite the authors of such recommendations to attend the meetings of the Conference in order to give verbal explanations of their objects and of the precise way in which they desire these to be carried into effect.

(iv) It shall be the duty of the Delegates to make themselves familiar with the purport of the several recommendations brought before the Conference, in order that they may be able to bring such recommendations adequately before their respective Societies.

(v) The Conference may also discuss propositions regarding the promotion of more systematic observation and plans of operation, and of greater uniformity in the method of publishing results.

CHAPTER XII.

Amendments and New Rules.

Alterations.

Any alterations in the Rules, and any amendments or new Rules that may be proposed by the Council or individual Members, shall be notified to the General Committee on the first day of the Annual Meeting, and referred forthwith to the Committee of Recommendations; and, on the report of that Committee, shall be submitted for approval at the last meeting of the General Committee.

Table showing the Places and Dates of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
VISCOUNT MILTON, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., Esq., F.G.S. Professor Phillips, M.A., F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S., F.R.S.E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, Esq., F.R.S., Astronomer Royal, &c. John Dalton, Esq., D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
SIR T. MACDOUGALL BRISBANE, K.C.B., D.C.L., F.R.S., F.R.S.E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S., F.R.S.E., &c. Sir John Robinson, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astronomer-Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, Esq., M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chancellor of the University of London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, Esq., D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Esq., Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, Esq., F.L.S., &c. Wm. Hutton, Esq., F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S. &c. BIRMINGHAM, August 26, 1839.	The Marquis of Northampton. The Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. The Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, Esq., M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The MARQUIS OF BREADALBANE, F.R.S. Glasgow, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount-Edgcumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. Plymouth, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. Manchester, June 23, 1842.	John Dalton, Esq., D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, Esq., M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, Esq., M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. Cork, August 17, 1843.	The Earl of Listowel. Viscount Adare. Sir W. R. Hamilton, Pres. R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.
The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. York, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. Rev. W. V. Harcourt, F.R.S.	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. Cambridge, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich. Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. G. B. Airy, Esq., M.A., D.C.L., F.R.S. The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.St.S., F.R.S. Southampton, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L. Lord Ashburton, D.C.L. Viscount Palmerston, M.P. Right Hon. Charles Shaw Lefevre, M.P. Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. The Lord Bishop of Oxford, F.R.S. Professor Owen, M.D., F.R.S. The Rev. Professor Powell, F.R.S.	Henry Clark, Esq., M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford Oxford, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. The Vice-Chancellor of the University Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. The Very Rev. the Dean of Westminster, D.D., F.R.S. Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. H. Wentworth Acland, Esq., B.M.

The MARQUIS OF NORTHAMPTON, President of the Royal Society, &c. SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Sir H. T. De la Beche, F.R.S., Pres. G.S. The Very Rev. the Dean of Llandaff, F.R.S. Lewis W. Dillwyn, Esq., F.R.S. J. H. Vivian, Esq., M.P., F.R.S. Viscount Adare, F.R.S. W. R. Grove, Esq., F.R.S. The Lord Bishop of St. Davids	Matthew Moggridge, Esq. D. Nicol, Esq., M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Right Hon. Sir Robert Peel, Bart., M.P., D.C.L., F.R.S. Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. Professor Faraday, D.C.L., F.R.S. Sir David Brewster, K.H., LL.D., F.R.S. The Lord Wrottesley, F.R.S. Rev. Prof. Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S., F.R.S.E., Principal of the United College of St. Salvator and St. Leonard, St. Andrews EDINBURGH, July 21, 1850.	The Right Hon. the Lord Provost of Edinburgh The Earl of Cathcart, K.C.B., F.R.S.E. The Earl of Rosebery, K.T., D.C.L., F.R.S. The Right Hon. David Boyle (Lord Justice-General), F.R.S.E. General Sir Thomas M. Brisbane, Bart., D.C.L., F.R.S., Pres. R.S.E. The Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E. Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S., F.R.S.E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.E.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer-Royal IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. Rev. Professor Sedgwick, M.A., F.R.S. Rev. Professor Henslow, M.A., F.L.S. Sir John P. Boileau, Bart., F.R.S. J. C. Cobbold, Esq., M.P. The Lord Bishop of Norwich Sir William F. F. Middleton, Bart. T. B. Western, Esq.	Charles May, Esq., F.R.A.S. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq., F.L.S.
COLONEL EDWARD SABINE, Royal Artillery, Treas. & V.P. of the Royal Society. BELFAST, September 1, 1852.	The Earl of Enniskillen, D.C.L., F.R.S. The Earl of Rosse, Pres. R.S., M.R.I.A. Sir Henry T. De la Beche. F.R.S. Rev. Edward Hincks, D.D., M.R.I.A. Rev. P. S. Henry, D.D., Pres. Queen's College, Belfast Rev. T. R. Robinson, D.D., Pres. R.I.A., F.R.A.S. Professor G. G. Stokes, F.R.S. Professor Stevelly, LL.D	W. J. C. Allen, Esq. William M'Gee, Esq., M.D. Professor W. P. Wilson.
WILLIAM HOPKINS, Esq., M.A., V.P.R.S., F.G.S., Pres. Camb. Phil. Society HULL, September 7 1853.	The Earl of Carlisle, F.R.S. Professor Faraday, D.C.L., F.R.S. Charles Frost, Esq., F.S.A., Pres. of the Hull Lit. and Phil. Society William Spence, Esq., F.R.S. Professor Wheatstone, F.R.S. Lord Londesborough, F.R.S. Rev. Prof. Sedgwick, M.A., F.R.S. Lieut.-Col. Sykes, F.R.S.	Henry Cooper, Esq., M.D., V.P. Hull Lit. & Phil. Society. Bethel Jacobs, Esq., Pres. Hull Mechanics' Inst.
The EARL OF HARROWBY, F.R.S. LIVERPOOL, September 20, 1854.	The Lord Wrottesley, M.A., F.R.S., F.R.A.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Professor Owen, M.D., LL.D., F.R.S., F.L.S., F.G.S. Rev. Professor Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., Master of Trinity College, Cambridge William Lassell, Esq., F.R.S., F.R.S.E., F.R.A.S. Joseph Brooks Yates, Esq., F.S.A., F.R.G.S.	Joseph Dickinson, Esq., M.D., F.R.S. Thomas Inman, Esq., M.D.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The DUKE OF ARGYLL, F.R.S., F.G.S. GLASGOW, September 12, 1855.	The Very Rev. Principal Macfarlane, D.D. Sir William Jardine, Bart., F.R.S.E. Sir Charles Lyell, M.A., LL.D., F.R.S. James Smith, Esq., F.R.S., F.R.S.E. Walter Crum, Esq., F.R.S. Thomas Graham, Esq., M.A., F.R.S., Master of the Royal Mint Professor William Thomson, M.A., F.R.S.	John Strang, Esq., LL.D. Professor Thomas Anderson, M.D. William Gourlie, Esq.
CHARLES G. B. DAUBENY, Esq., M.D., LL.D., F.R.S., Professor of Botany in the University of Oxford CHELTENHAM, August 6, 1856.	The Earl of Ducie, F.R.S., F.G.S. The Lord Bishop of Gloucester and Bristol Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. Thomas Barwick Lloyd Baker, Esq. The Rev. Francis Close, M.A.	Capt. Robinson, R.A. Richard Beamish, Esq., F.R.S. John West Hugell, Esq.
The REV. HUMPHREY LLOYD, D.D., D.C.L., F.R.S., F.R.S.E., V.P.R.I.A. DUBLIN, August 26, 1857.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin The Marquis of Kildare. Lord Talbot de Malahide The Lord Chancellor of Ireland The Lord Chief Baron, Dublin Sir William R. Hamilton, LL.D., F.R.A.S., Astronomer-Royal of Ireland Lieut.-Colonel Larcom, R.E., LL.D., F.R.S. Richard Griffith, Esq., LL.D., M.R.I.A., F.R.S.E., F.G.S.	Lundy E. Foote, Esq. Rev. Professor Jellett, F.T.C.D. W. Neilson Hancock, Esq., LL.D.
RICHARD OWEN, Esq., M.D., D.C.L., V.P.R.S., F.L.S., F.G.S., Superintendent of the Natural History Departments of the British Museum. LEEDS, September 22, 1858.	The Lord Monteagle, F.R.S. The Lord Viscount Goderich, M.P., F.R.G.S. The Right Hon. M. T. Baines, M.A., M.P. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. The Rev. W. Whewell, D.D., F.R.S., Hon. M.R.I.A., F.G.S., F.R.A.S., Master of Trinity College, Cambridge James Garth Marshall, Esq., M.A., F.G.S. R. Monckton Milnes, Esq., D.C.L., M.P., F.R.G.S.	Rev. Thomas Hincks, B.A. W. Sykes Ward, Esq., F.C.S. Thomas Wilson, Esq., M.A.
HIS ROYAL HIGHNESS THE PRINCE CONSORT. ABERDEEN, September 14, 1859.	The Duke of Richmond, K.G., F.R.S. The Earl of Aberdeen, LL.D., K.G., K.T., F.R.S. The Lord Provost of the City of Aberdeen Sir John F. W. Herschel, Bart., M.A., D.C.L., F.R.S. Sir David Brewster, K.H., D.C.L., F.R.S. Sir Roderick I. Murchison, G.C.St.S., D.C.L., F.R.S. The Rev. W. V. Harcourt, M.A., F.R.S. The Rev. T. R. Robinson, D.D., F.R.S. A. Thomson, Esq., LL.D., F.R.S., Convener of the County of Aberdeen	Professor J. Nicol, F.R.S.E., F.G.S. Professor Fuller, M.A. John F. White, Esq.
The LORD WROTTESLEY, M.A., V.P.R.S., F.R.A.S. OXFORD, June 27, 1860.	The Earl of Derby, K.G., P.C., D.C.L., Chancellor of the Univ. of Oxford The Rev. F. Jeune, D.C.L., Vice-Chancellor of the University of Oxford The Duke of Marlborough, D.C.L., F.G.S., Lord Lieutenant of Oxfordshire The Earl of Rosse, K.P., M.A., F.R.S., F.R.A.S. The Lord Bishop of Oxford, D.D., F.R.S. The Very Rev. H. G. Liddell, D.D., Dean of Christ Church, Oxford Professor Daubeny, M.D., LL.D., F.R.S., F.L.S., F.G.S. Professor Acland, M.D., F.R.S. Professor Donkin, M.A., F.R.S., F.R.A.S.	George Rolleston, Esq., M.D., F.L.S. H. J. S. Smith, Esq., M.A., F.C.S. George Griffith, Esq., M.A., F.C.S.

WILLIAM FAIRBAIRN, Esq., LL.D., C.E., F.R.S. MANCHESTER, September 4, 1861.	The Earl of Ellesmere, F.R.G.S. The Lord Stanley, M.P., D.C.L., F.R.G.S. The Lord Bishop of Manchester, D.D., F.R.S., F.G.S. Sir Philip de Malpas Grey Egerton, Bart., M.P., F.R.S., F.G.S. Sir Benjamin Heywood, Bart., F.R.S. Thomas Bazley, Esq., M.P. James Aspinall Turner, Esq., M.P. James Prescott Joule, Esq., LL.D., F.R.S., Pres. Lit. & Phil. Soc. Manchester Professor E. Hodgkinson, F.R.S., M.R.I.A., M.Inst.C.E. Joseph Whitworth, Esq., F.R.S., M.Inst.C.E.	R. D. Darbishire, Esq., B.A., F.G.S. Alfred Neild, Esq. Arthur Ransome, Esq., M.A. Professor H. E. Roscoe, B.A.
The REV. R. WILLIS, M.A., F.R.S., Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge CAMBRIDGE, October 1, 1862.	The Rev. the Vice-Chancellor of the University of Cambridge The Very Rev. Harvey Goodwin, D.D., Dean of Ely The Rev. W. Whewell, D.D., F.R.S., Master of Trinity College, Cambridge The Rev. Professor Sedgwick, M.A., D.C.L., F.R.S. The Rev. J. Challis, M.A., F.R.S G. B. Airy, Esq., M.A., D.C.L., F.R.S., Astronomer Royal Professor G. G. Stokes, M.A., D.C.L., Sec. R.S. Professor J. C. Adams, M A., D.C.L., F.R.S., Pres. C.P.S.	Professor C. C. Babington, M.A., F.R.S., F.L.S. Professor G. D. Liveing, M.A. The Rev. N. M. Ferrers, M.A.
SIR W. ARMSTRONG, C.B., LL.D., F.R.S. NEWCASTLE-ON-TYNE, August 26, 1863.	Sir Walter C. Trevelyan, Bart., M.A. Sir Charles Lyell, LL.D., D.C.L., F.R.S., F.G.S. Hugh Taylor, Esq., Chairman of the Coal Trade Isaac Lowthian Bell, Esq., Mayor of Newcastle Nicholas Wood, Esq., President of the Northern Institute of Mining Engineers Rev. Temple Chevallier, B.D., F.R.A.S. William Fairbairn, Esq., LL.D., F.R.S.	A. Noble, Esq. Augustus H. Hunt, Esq. R. C. Clapham, Esq.
SIR CHARLES LYELL, Bart., M.A., D.C.L., F.R.S. BATH, September 14, 1864.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somersetshire The Most Noble the Marquis of Bath The Right Hon. Earl Nelson The Right Hon. Lord Portman The Very Rev. the Dean of Hereford The Venerable the Archdeacon of Bath W. Tite, Esq., M.P., F.R.S., F.G.S., F.S.A. A. E. Way, Esq., M.P. Francis H. Dickinson, Esq. W. Sanders, Esq., F.R.S., F.G.S.	C. Moore, Esq., F.G.S. C. E. Davis, Esq. The Rev. H. H. Winwood, M.A.
JOHN PHILLIPS, Esq., M.A., LL.D., F.R.S., F.G.S., Professor of Geology in the University of Oxford BIRMINGHAM, September 6, 1865.	The Right Hon. the Earl of Lichfield, Lord-Lieutenant of Staffordshire The Right Hon. the Earl of Dudley The Right Hon. Lord Leigh, Lord-Lieutenant of Warwickshire The Right Hon. Lord Lyttelton, Lord-Lieutenant of Worcestershire The Right Hon. Lord Wrottesley, M.A., D.C.L., F.R.S., F.R.A.S. The Right Rev. the Lord Bishop of Worcester The Right Hon. C. B. Adderley, M.P. William Scholefield, Esq., M P. F. Osler, Esq., F.R.S. J. T. Chance, Esq. The Rev. Charles Evans, M.A.	William Mathews, jun., Esq., M.A., F.G.S. John Henry Chamberlain, Esq. The Rev. G. D. Boyle, M.A.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
WILLIAM R. GROVE, Esq., Q.C., M.A., F.R.S. NOTTINGHAM, August 22, 1866.	His Grace the Duke of Devonshire, Lord-Lieutenant of Derbyshire His Grace the Duke of Rutland, Lord-Lieutenant of Leicestershire The Right Hon. Lord Belper, Lord-Lieutenant of Nottinghamshire The Right Hon. J. E. Denison, M.P. J. C. Webb, Esq., High-Sheriff of Nottinghamshire Thomas Graham, Esq., F.R.S., Master of the Mint Joseph Hooker, Esq., M.D., F.R.S., F.L.S. John Russell Hind, Esq., F.R.S., F.R.A.S. T. Close, Esq.	Dr. Robertson. Edward J. Lowe, Esq., F.R.A.S., F.L.S. The Rev. J. F. M'Callan, M.A.
HIS GRACE THE DUKE OF BUCCLEUCH, K.G., D.C.L., F.R.S. DUNDEE, September 4, 1867.	The Right Hon. the Earl of Airlie, K.T. The Right Hon. the Lord Kinnaird, K.T. Sir John Ogilvy, Bart., M.P. Sir Roderick I. Murchison, Bart., K.C.B., LL.D., F.R.S., F.G.S., &c. Sir David Baxter, Bart. Sir David Brewster, D.C.L., F.R.S., Principal of the University of Edinburgh James D. Forbes, Esq., LL.D., F.R.S., Principal of the United College of St. Salvator and St. Leonard, University of St. Andrews	J. Henderson, jun., Esq. John Austin Lake Gloag, Esq. Patrick Anderson, Esq.
JOSEPH DALTON HOOKER, Esq., M.D., D.C.L., F.R.S., F.L.S. NORWICH, August 19, 1868.	The Right Hon. the Earl of Leicester, Lord-Lieutenant of Norfolk Sir John Peter Boileau, Bart., F.R.S. The Rev. Adam Sedgwick, M.A., LL.D., F.R.S., F.G.S., &c., Woodwardian Professor of Geology in the University of Cambridge Sir John Lubbock, Bart., F.R.S., F.L.S., F.G.S. John Couch Adams, Esq., M.A., D.C.L., F.R.S., F.R.A.S., Lowndean Professor of Astronomy and Geometry in the University of Cambridge Thomas Brightwell, Esq.	Dr. Donald Dalrymple. Rev. Joseph Crompton, M.A. Rev. Canon Hinds Howell.
PROFESSOR GEORGE G. STOKES, D.C.L., F.R.S. EXETER, August 18, 1869.	The Right Hon. the Earl of Devon The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., &c. Sir John Bowring, LL.D., F.R.S. William B. Carpenter, Esq., M.D., F.R.S., F.L.S. Robert Were Fox, Esq., F.R.S. W. H. Fox Talbot, Esq., M.A., LL.D., F.R.S., F.L.S.	Henry S. Ellis, Esq., F.R.A.S. John C. Bowring, Esq. The Rev. R. Kirwan.
PROFESSOR T. H. HUXLEY, LL.D., F.R.S., F.G.S. LIVERPOOL, September 14, 1870.	The Right Hon. the Earl of Derby, LL.D., F.R.S. Sir Philip de Malpas Grey Egerton, Bart., M.P. The Right Hon. W. E. Gladstone, D.C.L., M.P. S. R. Graves, Esq., M.P. Sir Joseph Whitworth, Bart., LL.D., D.C.L., F.R.S. James P. Joule, Esq., LL.D., D.C.L., F.R.S. Joseph Mayer, Esq., F.S.A., F.R.G.S.	Rev. W. Banister. Reginald Harrison, Esq. Rev. Henry H. Higgins, M.A. Rev. Dr. A. Hume, F.S.A.

PROFESSOR SIR WILLIAM THOMSON, M.A., LL.D., F.R.S., F.R.S.E. EDINBURGH, August 2, 1871.	His Grace the Duke of Buccleuch, K.G., D.C.L., F.R.S. The Right Hon. the Lord Provost of Edinburgh The Right Hon. John Inglis, LL.D., Lord Justice-General of Scotland Sir Alexander Grant, Bart., M.A., Principal of the University of Edinburgh Sir Roderick I. Murchison, Bart., K.C.B., G.C.St.S., D.C.L., F.R.S. Sir Charles Lyell, Bart., D.C.L., F.R.S., F.G.S. Dr. Lyon Playfair, C.B., M.P., F.R.S. Professor Christison, M.D., D.C.L., Pres. R.S.E. Professor Balfour, F.R.S., F.R.S.E.	Professor A. Crum Brown, M.D., F.R.S.E. J. D. Marwick, Esq., F.R.S.E.
W. B. CARPENTER, Esq., M.D., LL.D., F.R.S., F.L.S. BRIGHTON, August 14, 1872.	The Right Hon. the Earl of Chichester, Lord-Lieutenant of the County of Sussex. His Grace the Duke of Norfolk His Grace the Duke of Richmond, K.G., P.C., D.C.L. His Grace the Duke of Devonshire, K.G., D.C.L., F.G.S. Sir John Lubbock, Bart., M.P., F.R.S., F.L.S., F.G.S. Dr. Sharpey, LL.D., Sec. R.S., F.L.S. Joseph Prestwich, Esq., F.R.S., Pres. G.S.	Charles Carpenter, Esq. The Rev. Dr. Griffith. Henry Willett, Esq.
PROFESSOR ALEXANDER W. WILLIAMSON, Ph.D., F.R.S., F.C.S. BRADFORD, September 17, 1873.	The Right Hon. the Earl of Rosse, F.R.S., F.R.A.S. The Right Hon. Lord Houghton, D.C.L., F.R.S. The Right Hon. W. E. Forster, M.P. The Mayor of Bradford. Sir John Hawkshaw, F.R.S., F.G.S. J. P. Gassiot, Esq., D.C.L., F.R.S. Professor Phillips, D.C.L., F.R.S.	The Rev. J. R. Campbell, D.D. Richard Goddard, Esq. Peile Thompson, Esq.
PROFESSOR J. TYNDALL, D.C.L., LL.D., F.R.S. BELFAST, August 19, 1874.	The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S. The Right Hon. the Earl of Rosse, F.R.S. Sir Richard Wallace, Bart., M.P. The Rev. Dr. Henry. Dr. Andrews, F.R.S. The Rev. Dr. Robinson, F.R.S. Professor Stokes, D.C.L., F.R.S.	W. Quartus Ewart, Esq. Professor G. Fuller, C.E. T. Sinclair, Esq.
SIR JOHN HAWKSHAW, M.Inst.C.E., F.R.S., F.G.S. BRISTOL, August 25, 1875.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P., F.R.S. The Mayor of Bristol Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., F.R.G.S. Dr. W. B. Carpenter, LL.D., F.R.S., F.L.S., F.G.S. W. Sanders, Esq., F.R.S., F.G.S.	W. Lant Carpenter, Esq., B.A., B.Sc., F.C.S. John H. Clarke, Esq.
PROFESSOR THOMAS ANDREWS, M.D., LL.D., F.R.S., Hon. F.R.S.E. GLASGOW, September 6, 1876.	His Grace the Duke of Argyll, K.T., LL.D., F.R.S., F.R.S.E., F.G.S. The Hon. the Lord Provost of Glasgow Sir William Stirling Maxwell, Bart., M.A., M.P. Professor Sir William Thomson, M.A., LL.D., D.C.L., F.R.S., F.R.S.E. Professor Allen Thomson, M.D., LL.D., F.R.S., F.R.S.E. Professor A. C. Ramsay, LL.D., F.R.S., F.G.S. James Young, Esq., F.R.S., F.C.S.	Dr. W. G. Blackie, F.R.G.S. James Grahame, Esq. J. D. Marwick, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
PROFESSOR ALLEN THOMSON, M.D., LL.D., F.R.S., F.R.S.E. PLYMOUTH, August 15, 1877.	The Right Hon. the Earl of Mount-Edgcumbe The Right Hon. Lord Blachford, K.C.M.G. William Spottiswoode, Esq., M.A., LL.D., F.R.S., F.R.A.S., F.R.G.S. William Froude, Esq., M.A., C.E., F.R.S. Charles Spence Bate, Esq., F.R.S., F.L.S.	William Adams, Esq. William Square, Esq. Hamilton Whiteford, Esq.
WILLIAM SPOTTISWOODE, Esq., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. DUBLIN, August 14, 1878.	The Right Hon. the Lord Mayor of Dublin The Provost of Trinity College, Dublin His Grace the Duke of Abercorn, K.G. The Right Hon. the Earl of Enniskillen, D.C.L., F.R.S., F.G.S. The Right Hon. the Earl of Rosse, B.A., D.C.L., F.R.S., F.R.A.S., M.R.I.A. The Right Hon. Lord O'Hagan, M.R.I.A. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S.	Professor R. S. Ball, M.A., F.R.S. James Goff, Esq. John Norwood, Esq., LL.D. Professor G. Sigerson, M.D.
PROFESSOR G. J. ALLMAN, M.D., LL.D., F.R.S., F.R.S.E., M.R.I.A., Pres. L.S. SHEFFIELD, August 20, 1879.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Hon. the Earl of Wharncliffe, F.R.G.S. W. H. Brittain, Esq. (Master Cutler) Professor T. H. Huxley, Ph.D., LL.D., Sec. R.S., F.L.S., F.G.S. Professor W. Odling, M.B., F.R.S., F.C.S.	H. Clifton Sorby, Esq., LL.D., F.R.S., F.G.S. J. F. Moss, Esq.
ANDREW CROMBIE RAMSAY, Esq., LL.D., F.R.S., V.P.G.S., Director-General of the Geological Survey of the United Kingdom and of the Museum of Practical Geology SWANSEA, August 25, 1880.	The Right Hon. the Earl of Jersey The Mayor of Swansea The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. H. Hussey Vivian, Esq., M.P., F.G.S. L. Ll. Dillwyn, Esq., M.P., F.L.S., F.G.S. J. Gwyn Jeffreys, Esq., LL.D., F.R.S., F.L.S., Treas. G.S., F.R.G.S.	W. Morgan Esq., Ph.D., F.C.S. James Strick, Esq.
SIR JOHN LUBBOCK, Bart., M.P., D.C.L., LL.D., F.R.S., Pres. L.S., F.G.S. YORK, August 31, 1881.	His Grace the Archbishop of York, D.D., F.R.S. The Right Hon. the Lord Mayor of York The Right Hon. Lord Houghton, D.C.L., F.R.S., F.R.G.S. The Venerable Archdeacon Creyke, M.A. The Hon. Sir W. R. Grove, M.A., D.C.L., F.R.S. Professor G. G. Stokes, M.A., D.C.L., LL.D., Sec. R.S. Sir John Hawkshaw, M.Inst.C.E., F.R.S., F.G.S., F.R.G.S. Allen Thomson, Esq., M.D., LL.D., F.R.S., F.R.S.E. Professor Allman, M.D., LL.D., F.R.S.L., F.R.S.E., F.L.S.	Rev. Thomas Adams, M.A. Tempest Anderson, Esq., M.D., B.Sc.
W. SIEMENS, Esq., D.C.L., LL.D., F.R.S., F.C.S., M.Inst.C.E. SOUTHAMPTON, August 23, 1882.	The Right Hon. the Lord Mount-Temple Captain Sir F. J. Evans, K.C.B., F.R.S., F.R.A.S., F.R.G.S., Hydrographer to the Admiralty F. A. Abel, Esq., C.B., F.R.S., V.P.C.S., Director of the Chemical Establishment of the War Department Professor De Chaumont, M.D., F.R.S. Major-General A. C. Cooke, R.E., C.B., F.R.G.S., Director-General of the Ordnance Survey. Wyndham S. Portal, Esq. Professor Prestwich, M.A., F.R.S., F.G.S., F.C.S. Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S., F.L.S., F.G.S.	C. W. A. Jellicoe, Esq. John E. Le Feuvre, Esq. Morris Miles, Esq.

ARTHUR CAYLEY, Esq., M.A., D.C.L., LL.D., F.R.S., V.P.R.A.S., Sadlerian Professor of Pure Mathematics in the University of Cambridge SOUTHPORT, September 19, 1883.	The Right Hon. the Earl of Derby, M.A., LL.D., F.R.S., F.R.G.S. The Right Hon. the Earl of Crawford and Balcarres, LL.D., F.R.S., F.R.A.S. The Right Hon. the Earl of Lathom Principal J. W. Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. J. G. Greenwood, Esq., LL.D., Vice-Chancellor of the Victoria University Professor H. E. Roscoe, Ph.D., LL.D., F.R.S., F.C.S.	J. H. Ellis, Esq. Dr. Vernon. T. W. Willis, Esq.
The RIGHT HON. LORD RAYLEIGH, M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S., Professor of Experimental Physics in the University of Cambridge. MONTREAL, August 27, 1884.	His Excellency the Governor-General of Canada, G.C.M.G., LL.D. The Right Hon. Sir John Alexander Macdonald, K.C.B., D.C.L., LL.D. The Right Hon. Sir Lyon Playfair, K.C.B., M.P., LL.D., F.R.S. L. & E. The Hon. Sir Alexander Tilloch Galt, G.C.M.G. The Hon. Sir Charles Tupper, K.C.M.G. Chief Justice Sir A. A. Dorion, C.M.G. Principal Sir William Dawson, C.M.G., M.A., LL.D., F.R.S., F.G.S. The Hon. Dr. Chauveau Professor Edward Frankland, M.D., D.C.L., Ph.D., LL.D., F.R.S., F.C.S. W. H. Hingston, Esq., M.D., D.C.L., L.R.C.S.E. Thomas Sterry Hunt, Esq., M.A., D.Sc., LL.D., F.R.S.	S. E. Dawson, Esq. R. A. Ramsay, Esq. S. Rivard, Esq. S. C. Stevenson, Esq. Thos. White, Esq., M.P.
The RIGHT HON. SIR LYON PLAYFAIR, K.C.B., M.P., Ph.D., LL.D., F.R.S., F.R.S.E., F.C.S. ABERDEEN, September 9, 1885.	His Grace the Duke of Richmond and Gordon, K.G., D.C.L., Chancellor of the University of Aberdeen The Right Hon. the Earl of Aberdeen, LL.D., Lord-Lieutenant of Aberdeenshire The Right Hon. the Earl of Crawford and Balcarres, M.A., LL.D., F.R.S., F.R.A.S. James Matthews, Esq., Lord Provost of the City of Aberdeen Professor Sir William Thomson, M.A., LL.D., F.R.S., F.R.S.E., F.R.A.S. Alexander Bain, Esq., M.A., LL.D., Rector of the University of Aberdeen The Very Rev. Principal Pirie, D.D., Vice-Chancellor of the University of Aberdeen Professor W. H. Flower, LL.D., F.R.S., F.L.S., Pres. Z.S., F.G.S., Director of the Natural History Museum, London Professor John Struthers, M.D., LL.D.	J. W. Crombie, Esq., M.A. Angus Fraser, Esq., M.A., M.D., F.C.S. Professor G. Pirie, M.A.
SIR J. WILLIAM DAWSON, C.M.G., M.A., LL.D., F.R.S., F.G.S., Principal and Vice-Chancellor of McGill University, Montreal, Canada BIRMINGHAM, September 1, 1886.	The Right Hon. the Earl of Bradford, Lord-Lieutenant of Shropshire. The Right Hon. Lord Leigh, D.C.L., Lord-Lieutenant of Warwickshire. The Right Hon. Lord Norton, K.C.M.G. The Right Hon. Lord Wrottesley, Lord-Lieutenant of Staffordshire The Right Rev. the Lord Bishop of Worcester, D.D. Thomas Martineau, Esq., Mayor of Birmingham Professor G. G. Stokes, M.A., D.C.L., LL.D., Pres. R.S. Professor W. A. Tilden, D.Sc., F.R.S., F.C.S. Rev. A. R. Vardy, M.A. Rev. H. W. Watson, D.Sc., F.R.S.	J. Barham Carslake, Esq. Rev. H. W. Crosskey, LL.D., F.G.S. Charles J. Hart, Esq.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
SIR H. E. ROSCOE, M.P., D.C.L., LL.D., Ph.D., F.R.S., V.P.C.S. MANCHESTER, August 31, 1887.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S., F.R.G.S. The Right Hon. the Earl of Derby, K.G., M.A., LL.D., F.R.S., F.R.G.S. The Right Rev. the Lord Bishop of Manchester, D.D. The Right Rev. the Bishop of Salford The Right Worshipful the Mayor of Manchester The Right Worshipful the Mayor of Salford The Vice-Chancellor of the Victoria University The Principal of the Owens College Sir William Roberts, B.A., M.D., F.R.S. Thomas Ashton, Esq., J.P., D.L. Oliver Heywood, Esq., J.P., D.L. James Prescott Joule, Esq., D.C.L., LL.D., F.R.S., F.R.S.E., F.C.S.	F. J. Faraday, Esq., F.L.S., F.S.S. Charles Hopkinson, Esq., B.Sc. Professor A. Milnes Marshall, M.A., M.D., D.Sc., F.R.S. Professor A. H. Young, M.B., F.R.C.S.
SIR FREDERICK J. BRAMWELL, D.C.L., F.R.S., M.Inst.C.E. BATH, September 5, 1888.	The Right Hon. the Earl of Cork and Orrery, Lord-Lieutenant of Somerset The Most Hon. the Marquess of Bath The Right Hon. and Right Rev. the Lord Bishop of Bath and Wells, D.D. The Right Rev. the Bishop of Clifton, D.D. The Right Worshipful the Mayor of Bath The Right Worshipful the Mayor of Bristol Sir F. A. Abel, C.B., D.C.L., F.R.S., V.P.C.S. The Venerable the Archdeacon of Bath, M.A. The Rev. Leonard Blomefield, M.A., F.L.S., F.G.S. Professor Michael Foster, M.A., M.D., LL.D., Sec. R.S., F.L.S., F.C.S. W. S. Gore-Langton, Esq., J.P., D.L. H. D. Skrine, Esq., J.P., D.L. E. R. Wodehouse, Esq., M.P. Colonel R. P. Laurie, C.B., M.P. Jerom Murch, Esq., J.P., D.L.	W. Pumphrey, Esq. J. L. Stothert, Esq., M.Inst.C.E. B. H. Watts, Esq.
PROFESSOR WILLIAM HENRY FLOWER, C.B., LL.D., F.R.S., F.R.C.S., Pres. Z.S., F.L.S., F.G.S., Director of the Natural History Departments of the British Museum NEWCASTLE-UPON-TYNE, September 11, 1889.	His Grace the Duke of Northumberland, K.G., D.C.L., LL.D., Lord-Lieutenant of Northumberland The Right Hon. the Earl of Durham, Lord-Lieutenant of Durham The Right Hon. the Earl of Ravensworth The Right Rev. the Lord Bishop of Newcastle, D.D. The Right Hon. Lord Armstrong, C.B., D.C.L., LL.D., F.R.S. The Right Hon. John Morley, M.P., LL.D. The Very Rev. the Warden of the University of Durham, D.D. The Right Worshipful the Mayor of Newcastle The Worshipful the Mayor of Gateshead Sir I. Lowthian Bell, Bart., D.C.L., F.R.S., F.C.S., M.Inst.C.E. Sir Charles Mark Palmer, Bart., M.P.	Professor P. Phillips Bedson, D.Sc., F.C.S. Professor J. Herman Merivale, M.A.

SIR FREDERICK AUGUSTUS ABEL, C.B., D.C.L., D.Sc., F.R.S., F.C.S., Hon.M.Inst.C.E. LEEDS, September 3, 1890.	His Grace the Duke of Devonshire, K.G., M.A., LL.D., F.R.S., F.G.S. The Most Hon. the Marquess of Ripon, K.G., G.C.S.I., C.I.E., F.R.S. The Right Hon. the Earl Fitzwilliam, K.G., F.R.G.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Sir Lyon Playfair, K.C.B., Ph.D., LL.D., M.P., F.R.S. The Right Hon. W. L. Jackson, M.P. Sir James Kitson, Bart., M.Inst.C.E. The Mayor of Leeds Sir Andrew Fairbairn, M.A.	J. Rawlinson Ford, Esq. Sydney Lupton, Esq., M.A. Professor L. C. Miall, F.L.S., F.G.S. Professor A. Smithells, B.Sc.
WILLIAM HUGGINS, Esq., D.C.L., LL.D., Ph.D., F.R.S., F.R.A.S., Hon. F.R.S.E. CARDIFF, August 19, 1891.	The Right Hon. Lord Windsor, Lord-Lieutenant of Glamorganshire The Most Hon. the Marquess of Bute, K.T. The Right Hon. Lord Rayleigh, M.A., D.C.L., LL.D., Sec.R.S., F.R.A.S. The Right Hon. Lord Tredegar The Right Hon. Lord Aberdare, G.C.B., F.R.S., F.R.G.S. Sir J. T. D. Llewelyn, Bart., F.Z.S. Sir Archibald Geikie, LL.D., D.Sc., For.Sec.R.S., F.R.S.E., Pres.G.S. Sir Robert Ball, LL.D., F.R.S., F.R.A.S., Royal Astronomer of Ireland	R. W. Atkinson, Esq., B.Sc., F.C.S., F.I.C. Professor H. W. Lloyd Tanner, M.A., F.R.A.S.
SIR ARCHIBALD GEIKIE, LL.D., D.Sc., For. Sec. R.S., F.R.S.E., F.G.S., Director-General of the Geological Survey of the United Kingdom EDINBURGH, August 3, 1892.	The Right Hon. the Lord Provost of Edinburgh The Most Hon. the Marquess of Lothian, K.T. The Right Hon. the Earl of Rosebery, LL.D., F.R.S., F.R.S.E. The Right Hon. J. H. A. Macdonald, C.B., LL.D., F.R.S., F.R.S.E. Principal Sir William Muir, K.C.S.I., D.C.L. Professor Sir Douglas Maclagan, M.D., Pres.R.S.E. Professor Sir William Turner, F.R.S., F.R.S.E. Professor P. G. Tait, M.A., F.R.S.E. Professor A. Crum Brown, M.D., F.R.S., F.R.S.E., Pres.C.S.	Professor G. F. Armstrong, M.A., M.Inst.C.E., F.R.S.E., F.G.S. F. Grant Ogilvie, Esq., M.A., B.Sc., F.R.S.E. John Harrison, Esq.
DR. J. S. BURDON SANDERSON, M.A., M.D., LL.D., D.C.L., F.R.S., F.R.S.E., Professor of Physiology in the University of Oxford NOTTINGHAM, September 13, 1893.	His Grace the Duke of St. Albans, Lord-Lieutenant of Nottinghamshire His Grace the Duke of Devonshire, K.G., Chancellor of the University of Cambridge His Grace the Duke of Portland His Grace the Duke of Newcastle The Right Hon. Lord Belper The Mayor of Nottingham The Right Hon. Sir W. R. Grove, F.R.S. Sir John Turney, J.P. Professor Michael Foster, M.A., Sec.R.S. W. H. Ransom, Esq., M.D., F.R.S.	Professor F. Clowes, D.Sc. Professor W. H. Heaton, M.A. Arthur Williams, Esq.

PRESIDENTS	VICE-PRESIDENTS.	LOCAL SECRETARIES.
The MOST HON. THE MARQUIS OF SALISBURY, K.G., D.C.L., F.R.S., Chancellor of the University of Oxford. OXFORD, August 8, 1894.	The Right Hon. the Earl of Jersey, G.C.M.G., Lord-Lieutenant of the County of Oxford. The Right Hon. Lord Wantage, K.C.B., V.C., Lord-Lieutenant of Berkshire The Right Hon. the Earl of Rosebery, K.G., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Oxford, D.D. The Right Hon. Lord Rothschild, Lord-Lieutenant of Buckinghamshire The Right Hon. Lord Kelvin, D.C.L., Pres.R.S. The Rev. the Vice-Chancellor of the University of Oxford. The Mayor of Oxford. Sir W. R. Anson, D.C.L., Warden of All Souls College. Sir Bernhard Samuelson, Bart., M.P., F.R.S. Sir Henry Dyke Acland, Bart., M.D., F.R.S., Regius Professor of Medicine The Rev. B. Price, D.D., F.R.S., Sedleian Professor of Natural Philosophy. Dr. J. J. Sylvester, F.R.S., Savilian Professor of Geometry	Gilbert C. Bourne, Esq., M.A. G. C. Druce, Esq., M.A. D. H. Nagel, Esq., M.A.
CAPTAIN SIR DOUGLAS GALTON, K.C.B., D.C.L., LL.D., F.R.S., F.R.G.S., F.G.S. IPSWICH, September 11, 1895.	The Most Hon. the Marquis of Bristol, M.A., Lord-Lieutenant of the County of Suffolk The Right Hon. Lord Walsingham, LL.D., F.R.S., High Steward of the University of Cambridge The Right Hon. Lord Rayleigh, Sec.R.S., Lord-Lieutenant of Essex The Right Hon. Lord Gwydyr, M.A., High Steward of Ipswich The Right Hon. Lord Henniker, F.S.A. The Right Hon. Lord Rendlesham J. H. Bartlet Esq., Mayor of Ipswich Sir G. G. Stokes, Bart., D.C.L., F.R.S. Dr. E. Frankland, D.C.L., F.R.S. Professor G. H. Darwin, M.A., F.R.S. Felix T. Cobbold, Esq., M.A.	G. H. Hewetson, Esq. S. A. Notcutt, Esq., B.A., LL.M., B.Sc. E. P. Ridley, Esq.
SIR JOSEPH LISTER, Bart., D.C.L., LL.D., President of the Royal Society LIVERPOOL, September 16, 1896.	The Right Hon. the Earl of Derby, G.C.B., Lord Mayor of Liverpool. The Right Hon. the Earl of Sefton, K.G., Lord-Lieutenant of Lancashire Sir W. B. Forwood, J.P. Sir Henry E. Roscoe, D.C.L., F.R.S. The Principal of University College, Liverpool W. Rathbone, Esq., LL.D. W. Crookes, Esq., F.R.S., V.P.C.S. T. H. Ismay, Esq., J.P., D.L. Professor A. Liversidge, F.R.S.	Professor W. A. Herdman, F.R.S. Isaac C. Thompson, Esq., F.L.S. W. E. Willink, Esq.
SIR JOHN EVANS, K.C.B., D.C.L., LL.D., Sc.D., Treas.R.S., F.S.A., For. Sec. G.S. TORONTO, August 18, 1897.	His Excellency the Right Hon. the Earl of Aberdeen, G.C.M.G., Governor-General of the Dominion of Canada The Right Hon. Lord Rayleigh, M.A., D.C.L., F.R.S. The Right Hon. Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S., F.R.S.E. The Hon. Sir Wilfrid Laurier, G.C.M.G., Prime Minister of the Dominion of Canada His Honour the Lieutenant-Governor of the Province of Ontario The Hon. the Premier of the Province of Ontario The Hon. the Minister of Education for the Province of Ontario The Hon. Sir Charles Tupper, Bart., G.C.M.G., C.B., LL.D. The Hon. Sir Donald A. Smith, G.C.M.G., LL.D., High Commissioner for Canada Sir William Dawson, C.M.G., F.R.S. The Mayor of Toronto Professor J. Loudon, M.A., LL.D., President of the University of Toronto	Professor A. B. Macallum, M.B., Ph.D. B. E. Walker, Esq., F.G.S. J. S. Willison, Esq.

SIR WILLIAM CROOKES, F.R.S., V.P.C.S. BRISTOL, September 7, 1898.	The Right Hon. the Earl of Ducie, F.R.S., F.G.S. The Right Rev. the Lord Bishop of Bristol, D.D. The Right Hon. Sir Edward Fry, D.C.L., F.R.S., F.S.A. Sir F. J. Bramwell, Bart., D.C.L., LL.D., F.R.S. The Right Worshipful the Mayor of Bristol The Principal of University College, Bristol The Master of the Society of Merchant Venturers of Bristol John Beddoe, Esq., M.D., LL.D., F.R.S. Professor T. G. Bonney, D.Sc., LL.D., F.R.S., F.S.A., F.G.S.	Arthur Lee, Esq., J.P. Bertram Rogers, Esq., M.D.
PROFESSOR SIR MICHAEL FOSTER, K.C.B., M.D., D.C.L., LL.D., Sec. R.S. DOVER, September 13, 1899.	His Grace the Lord Archbishop of Canterbury, D.D. The Most Hon. the Marquis of Salisbury, K.G., M.A., D.C.L., F.R.S. The Mayor of Dover The Major-General Commanding the South-Eastern District The Right Hon. A. Akers-Douglas, M.P. The Very Rev. F. W. Farrar, D.D., F.R.S., Dean of Canterbury Sir J. Norman Lockyer, K.C.B., F.R.S. Professor G. H. Darwin, M.A., LL.D., F.R.S., Pres. R.A.S.	E. Wollaston Knocker, Esq., C.B. W. H. Pendlebury, Esq., M.A.
PROFESSOR SIR WILLIAM TURNER, M.B., D.Sc., D.C.L., LL.D., F.R.S. BRADFORD, September 5, 1900.	The Right Hon. the Earl of Scarbrough, Lord-Lieutenant of the West Riding of Yorkshire His Grace the Duke of Devonshire, K.G., D.C.L., LL.D., F.R.S. The Most Hon. the Marquis of Ripon, K.G., G.C.S.I., D.C.L., F.R.S. The Right Rev. the Lord Bishop of Ripon, D.D. The Right Hon. Lord Masham His Worship the Mayor of Bradford The Hon. H. E. Butler, Lord of the Manor, Bradford Sir Alexander Binnie, M.Inst.C.E., F.G.S. Professor A. W. Rücker, M.A., D.Sc., Sec.R.S. Dr. T. E. Thorpe, Sc.D., F.R.S., Pres.C.S. Principal N. Bodington, Litt.D., Vice-Chancellor of the Victoria University Professor L. C. Miall, F.R.S.	Ramsden Bacchus, Esq. J. E. Fawcett, Esq., J.P. Frederick Stevens, Esq.
PROFESSOR A. W. RÜCKER, M.A., LL.D., D.Sc., Sec. R.S. GLASGOW, September 11, 1901.	The Right Hon. the Earl of Glasgow, G.C.M.G. The Right Hon. the Lord Blythswood, LL.D., D.L. The Right Hon. the Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S. Samuel Chisholm, Esq., the Hon. the Lord Provost of Glasgow Very Rev. R. Herbert Story, D.D., LL.D., Principal of the University of Glasgow Sir John Maxwell Stirling-Maxwell, Bart., M.P., D.L. Sir Andrew Noble, K.C.B., D.C.L., F.R.S. Sir Archibald Geikie, D.C.L., LL.D., F.R.S. Sir W. T. Thiselton-Dyer, K.C.M.G., C.I.E., F.R.S. James Parker Smith, Esq., M.P., D.L. John Inglis, Esq., LL.D. Professor John Cleland, M.D., LL.D., D.Sc., F.R.S.	Sir J. D. Marwick, LL.D., D.L., F.R.S.E. Professor John Young, M.D. Professor Magnus Maclean, D.Sc., F.R.S.E.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
FRANCIS DARWIN, M.A., M.B., LL.D., F.R.S. DUBLIN, September 2, 1908.	Right Hon. Alderman Gerald O'Reilly, Lord Mayor of Dublin Right Hon. Sir Samuel Walker, Bart., Lord Chancellor of Ireland Right Hon. Augustine Birrell, M.P., Chief Secretary to the Lord Lieutenant of Ireland Right Hon. the Earl of Meath, K.P., His Majesty's Lieutenant for the County of Dublin Right Hon. Lord Castletown of Upper Ossory, K.P., Chancellor of the Royal University of Ireland Anthony Traill, M.D., LL.D., Provost of Trinity College, Dublin Very Rev. William Delany, LL.D., President of University College, Dublin Right Hon. Viscount Iveagh, K.P., LL.D., F.R.S. Right Hon. Lord Ardilaun, D.L., LL.D., President of the Royal Dublin Society Francis A. Tarleton, LL.D., President of the Royal Irish Academy Right Hon. Mr. Justice Madden, M.A., LL.D., Vice-Chancellor of the University of Dublin Sir Christopher Nixon, Bart., M.D., LL.D., Vice-Chancellor of the Royal University of Ireland T. W. Russell, M.P., Vice-President of the Department of Agriculture and Technical Instruction in Ireland	Joseph McGrath, LL.D. John Mulligan, J.P. Professor W. H. Thompson, D.Sc., M.D. Professor W. E. Thrift, M.A.
PROFESSOR SIR J. J. THOMSON, M.A., Sc.D., D.Sc., F.R.S. WINNIPEG, August 25, 1909.	The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G., G.C.V.O., LL.D., High Commissioner in London for the Dominion of Canada The Right Hon. Sir Wilfrid Laurier, G.C.M.G., P.C., D.L., Prime Minister and President of Privy Council The Hon. Sir Daniel Hunter McMillan, K.C.M.G., Lieutenant-Governor of Manitoba The Hon. Rodmond Palen Roblin, Premier of Manitoba The Hon. Amedee E. Forget, Lieutenant-Governor of Saskatchewan The Hon. Walter Scott, Premier of Saskatchewan The Hon. George H. V. Bulyea, Lieutenant-Governor of Alberta The Hon. Alex. C. Rutherford, B.A., LL.D., Premier of Alberta The Hon. James Dunsmuir, Lieutenant-Governor of British Columbia The Hon. Richard McBride, LL.B., K.C., Premier of British Columbia	C. N. Bell. W. Sanford Evans. Professor M. A. Parker, B.Sc., F.C.S. Professor Swale Vincent, M.D., D.Sc.

REV. PROFESSOR T. G. BONNEY, Sc.D., LL.D., F.R.S. SHEFFIELD, August 31, 1910.	Right Hon. the Earl Fitzwilliam, D.S.O., Lord Mayor of Sheffield ..... Herbert Barber, Master Cutler of Sheffield .... His Grace the Lord Archbishop of York .... His Grace the Duke of Norfolk, E.M., K.G., G.C.V.O., Litt.D., Chancellor of Sheffield University... .... Right Hon. the Earl of Harewood, K.C.V.O., Lord-Lieutenant of the West Riding of Yorkshire .... George Franklin, Litt.D., J.P., Pro-Chancellor of Sheffield University Sir Charles Eliot, K.C.M.G., C.B., Vice Chancellor of Sheffield University Alderman H. K. Stephenson, J.P., Deputy Lord Mayor of Sheffield .... Right Rev. the Lord Bishop of Sheffield .... A. J. Hobson, J.P., President of the Sheffield Chamber of Commerce ... Alderman Sir William Clegg, J.P., Chairman of the Sheffield Education Committee.............. Colonel Herbert Hughes, C.M.G., J.P. .... Professor W. M. Hicks, Sc.D., F.R.S. .... Rev. E. H. Titchmarsh, M.A., President of the Sheffield Free Church Council	W. M. Gibbons, M.A. R. M. Prescott.
PROFESSOR SIR WILLIAM RAMSAY, K.C.B., Ph.D., LL.D., D.Sc., M.D., F.R.S.... .. .. PORTSMOUTH, August 30, 1911.	H.R.H. the Princess Henry of Battenberg .... Alderman T. Scott Foster, J.P., Mayor of Portsmouth .... His Grace the Lord Archbishop of Canterbury, G.C.V.O., D.D. . His Grace the Archbishop of York, D.D. ..... The Most Hon. the Marquess of Winchester, Lord-Lieutenant of the County of Hampshire .... Field-Marshal the Right Hon. the Earl Roberts, K.G., K.P., G.C.B., O.M., V.C. .... The Right Rev. the Lord Bishop of Winchester, D.D. .... The Right Hon. Lord Macnaghten, G.C.B., G.C.M.G. ..... Admiral Sir Arthur William Moore, G.C.B., K.C.V.O., C.M.G. . Major-General J. K. Trotter, C.B., C.M.G. .... Rear-Admiral A. G. Tate, R.N. .... Colonel Sir William T. Dupree, D.L., V.D., J.P. .... A. G. Vernon Harcourt, M.A., D.C.L., LL.D., D.Sc., F.R.S.	G. Hammond Etherton. A. Mearns Fraser, M.D.

TRUSTEES AND GENERAL OFFICERS, 1831-1911.

TRUSTEES.

1832-70 (Sir) R. I. Murchison (Bart.), F.R.S.
1832-62 John Taylor, Esq., F.R.S.
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1839-44 F. Baily, Esq., F.R.S.
1844-58 Rev. G. Peacock, F.R.S.
1858-82 General E. Sabine, F.R.S.
1862-81 Sir P. Egerton, Bart., F.R.S.
1872- Sir J. Lubbock, Bart. (now Lord Avebury), F.R.S.
1881-83 W. Spottiswoode, Esq., Pres. R.S.
1883- Lord Rayleigh, F.R.S.
1883-98 Sir Lyon (afterwards Lord) Playfair, F.R.S.
1898- Prof. (Sir) A. W. Rücker, F.R.S.

GENERAL TREASURERS.

1831 Jonathan Gray, Esq.
1832-62 John Taylor, Esq., F.R.S.
1862-74 W. Spottiswoode, Esq., F.R.S.
1874-91 Prof. A. W. Williamson, F.R.S.
1891-98 Prof. (Sir) A. W. Rücker, F.R.S.
1898-1904 Prof. G. C. Foster, F.R.S.
1904- Prof. John Perry, F.R.S.

GENERAL SECRETARIES.

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1835-36 Rev. W. Vernon Harcourt, F.R.S., and F. Baily, Esq., F.R.S.
1836-37 Rev. W. Vernon Harcourt, F.R.S., and R. I. Murchison, Esq., F.R.S.
1837-39 R. I. Murchison, Esq., F.R.S., and Rev. G. Peacock, F.R.S.
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1845-50 Lieut.-Colonel E. Sabine, F.R.S.
1850-52 General E. Sabine, F.R.S., and J. F. Royle, Esq., F.R.S.
1852-53 J. F. Royle, Esq., F.R.S.
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1859-61 Prof. R. Walker, F.R.S.
1861-62 W. Hopkins, Esq., F.R.S.
1862-63 W. Hopkins, Esq., F.R.S., and Prof. J. Phillips, F.R.S.
1863-65 W. Hopkins, Esq., F.R.S., and F. Galton, Esq., F.R.S.
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1871-72 Dr. T. Thomson, F.R.S., and Capt. Douglas Galton, F.R.S.
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1876-81 Capt. D. Galton, F.R.S., and Dr. P. L. Sclater, F.R.S.
1881-82 Capt. D. Galton, F.R.S., and Prof. F. M. Balfour, F.R.S.
1882-83 Capt. Douglas Galton, F.R.S.
1883-95 Sir Douglas Galton, F.R.S., and A. G. Vernon Harcourt, Esq., F.R.S.
1895-97 A. G. Vernon Harcourt, Esq., F.R.S., and Prof. E. A. Schäfer, F.R.S.
1897-1900 Prof. Schäfer, F.R.S., and Sir W. C. Roberts-Austen, F.R.S.
1900-02 Sir W. C. Roberts-Austen, F.R.S., and Dr. D. H. Scott, F.R.S.
1902-03 Dr. D. H. Scott, F.R.S., and Major P. A. MacMahon, F.R.S.
1903- Major P. A. MacMahon, F.R.S., and Prof. W. A. Herdman, F.R.S.

ASSISTANT GENERAL SECRETARIES, &c.: 1831-1904.

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1832-62 Prof. John Phillips, F.R.S.
1862-78 G. Griffith, Esq., M.A.
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1881 G. Griffith, Esq., M.A., *Acting Secretary.*
1881-85 Prof. T. G. Bonney, F.R.S., *Secretary.*
1885-90 A. T. Atchison, Esq., M.A., *Secretary.*
1890 G. Griffith, Esq., M.A., *Acting Secretary.*
1890-1902 G. Griffith, Esq., M.A.
1902-04 J. G. Garson, Esq., M.D.

ASSISTANT SECRETARIES.

1904-09 A. Silva White, Esq.
1909- O. J. R. Howarth, Esq., M.A.

Presidents and Secretaries of the Sections of the Association.

MATHEMATICAL AND PHYSICAL SCIENCES.

COMMITTEE OF SCIENCES, I.—MATHEMATICS AND GENERAL PHYSICS.

Date and Place	Presidents	Secretaries
1832. Oxford	Davies Gilbert, D.C.L., F.R.S.	Rev. H. Coddington.
1833. Cambridge	Sir D. Brewster, F.R.S.	Prof. Forbes.
1834. Edinburgh	Rev. W. Whewell, F.R.S.	Prof. Forbes, Prof. Lloyd.

SECTION A.—MATHEMATICS AND PHYSICS.

Date and Place	Presidents	Secretaries
1835. Dublin	Rev. Dr. Robinson	Prof. Sir W. R. Hamilton, Prof. Wheatstone.
1836. Bristol	Rev. William Whewell, F.R.S.	Prof. Forbes, W. S. Harris, F. W. Jerrard.
1837. Liverpool	Sir D. Brewster, F.R.S.	W. S. Harris, Rev. Prof. Powell, Prof. Stevelly.
1838. Newcastle	Sir J. F. W. Herschel, Bart., F.R.S.	Rev. Prof. Chevallier, Major Sabine, Prof. Stevelly.
1839. Birmingham	Rev. Prof. Whewell, F.R.S.	J. D. Chance, W. Snow Harris, Prof. Stevelly.
1840. Glasgow	Prof. Forbes, F.R.S.	Rev. Dr. Forbes, Prof. Stevelly, Arch. Smith.
1841. Plymouth	Rev. Prof. Lloyd, F.R.S.	Prof. Stevelly.
1842. Manchester	Very Rev. G. Peacock, D.D., F.R.S.	Prof. M'Culloch, Prof. Stevelly, Rev. W. Scoresby.
1843. Cork	Prof. M'Culloch, M.R.I.A.	J. Nott, Prof. Stevelly.
1844. York	The Earl of Rosse, F.R.S.	Rev. Wm. Hey, Prof. Stevelly.
1845. Cambridge	The Very Rev. the Dean of Ely.	Rev. H. Goodwin, Prof. Stevelly, G. G. Stokes.
1846. Southampton.	Sir John F. W. Herschel, Bart., F.R.S.	John Drew, Dr. Stevelly, G. G. Stokes.
1847. Oxford	Rev. Prof. Powell, M.A., F.R.S.	Rev. H. Price, Prof. Stevelly, G. G. Stokes.
1848. Swansea	Lord Wrottesley, F.R.S.	Dr. Stevelly, G. G. Stokes.
1849. Birmingham	William Hopkins, F.R.S.	Prof. Stevelly, G. G. Stokes, W. Ridout Wills.
1850. Edinburgh	Prof. J. D. Forbes, F.R.S., Sec. R.S.E.	W. J. Macquorn Rankine, Prof. Smyth, Prof. Stevelly, Prof. G. G. Stokes.
1851. Ipswich	Rev. W. Whewell, D.D., F.R.S.	S. Jackson, W. J. Macquorn Rankine, Prof. Stevelly, Prof. G. G. Stokes.
1852. Belfast	Prof. W. Thomson, M.A., F.R.S., F.R.S.E.	Prof. Dixon, W. J. Macquorn Rankine, Prof. Stevelly, J. Tyndall.
1853. Hull	The Very Rev. the Dean of Ely, F.R.S.	B. Blaydes Haworth, J. D. Sollitt, Prof. Stevelly, J. Welsh.
1854. Liverpool	Prof. G. G. Stokes, M.A., Sec. R.S.	J. Hartnup, H. G. Puckle, Prof. Stevelly, J. Tyndall, J. Welsh.
1855. Glasgow	Rev. Prof. Kelland, M.A., F.R.S., F.R.S.E.	Rev. Dr. Forbes, Prof. D. Gray, Prof. Tyndall.
1856. Cheltenham	Rev. R. Walker, M.A., F.R.S.	C. Brooke, Rev. T. A. Southwood, Prof. Stevelly, Rev. J. C. Turnbull.
1857. Dublin	Rev. T. R. Robinson, D.D., F.R.S., M.R.I.A.	Prof. Curtis, Prof. Hennessy, P. A. Ninnis, W. J. Macquorn Rankine, Prof. Stevelly.
1858. Leeds	Rev. W. Whewell, D.D., V.P.R.S.	Rev. S. Earnshaw, J. P. Hennessy, Prof. Stevelly, H. J. S. Smith, Prof. Tyndall.
1859. Aberdeen	The Earl of Rosse, M.A., K.P., F.R.S.	J. P. Hennessy, Prof. Maxwell, H. J. S. Smith, Prof. Stevelly.

Date and Place	Presidents	Secretaries
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1862. Cambridge	Prof. G. G. Stokes, M.A., F.R.S.	Prof. R. B. Clifton, Prof. H. J. S. Smith, Prof. Stevelly.
1863. Newcastle	Prof. W. J. Macquorn Rankine, C.E., F.R.S.	Rev. N. Ferrers, Prof. Fuller, F. Jenkin, Prof. Stevelly, Rev. C. T. Whitley.
1864. Bath.........	Prof. Cayley, M.A., F.R.S., F.R.A.S.	Prof. Fuller, F. Jenkin, Rev. G. Buckle, Prof. Stevelly.
1865. Birmingham	W. Spottiswoode, M.A., F.R.S., F.R.A.S.	Rev. T. N. Hutchinson, F. Jenkin, G. S. Mathews, Prof. H. J. S. Smith, J. M. Wilson.
1866. Nottingham	Prof. Wheatstone, D.C.L., F.R.S.	Fleeming Jenkin, Prof. H. J. S. Smith, Rev. S. N. Swann.
1867. Dundee ...	Prof. Sir W. Thomson, D.C.L., F.R.S.	Rev. G. Buckle, Prof. G. C. Foster, Prof. Fuller, Prof. Swan.
1868. Norwich ...	Prof. J. Tyndall, LL.D., F.R.S.	Prof. G. C. Foster, Rev. R. Harley, R. B. Hayward.
1869. Exeter......	Prof. J. J. Sylvester, LL.D., F.R.S.	Prof. G. C. Foster, R. B. Hayward, W. K. Clifford.
1870. Liverpool...	J. Clerk Maxwell, M.A., LL.D., F.R.S.	Prof. W. G. Adams, W. K. Clifford, Prof. G. C. Foster, Rev. W. Allen Whitworth.
1871. Edinburgh	Prof. P. G. Tait, F.R.S.E. ...	Prof. W. G. Adams, J. T. Bottomley, Prof. W. K. Clifford, Prof. J. D. Everett, Rev. R. Harley.
1872. Brighton...	W. De La Rue, D.C.L., F.R.S.	Prof. W. K. Clifford, J. W. L. Glaisher, Prof. A. S. Herschel, G. F. Rodwell.
1873. Bradford ...	Prof. H. J. S. Smith, F.R.S. .	Prof. W. K. Clifford, Prof. Forbes, J. W. L. Glaisher, Prof. A. S. Herschel.
1874. Belfast......	Rev. Prof. J. H. Jellett, M.A., M.R.I.A.	J. W. L. Glaisher, Prof. Herschel, Randal Nixon, J. Perry, G. F. Rodwell.
1875. Bristol......	Prof. Balfour Stewart, M.A., LL.D., F.R.S.	Prof. W. F. Barrett, J. W. L. Glaisher, C. T. Hudson, G. F. Rodwell.
1876. Glasgow ...	Prof. Sir W. Thomson, M.A., D.C.L., F.R.S.	Prof. W. F. Barrett, J. T. Bottomley, Prof. G. Forbes, J. W. L. Glaisher, T. Muir.
1877. Plymouth...	Prof. G. C. Foster, B.A., F.R.S., Pres. Physical Soc.	Prof. W. F. Barrett, J. T. Bottomley, J. W. L. Glaisher, F. G. Landon.
1878. Dublin......	Rev. Prof. Salmon, D.D., D.C.L., F.R.S.	Prof. J. Casey, G. F. Fitzgerald, J. W. L. Glaisher, Dr. O. J. Lodge.
1879. Sheffield ...	George Johnstone Stoney, M.A., F.R.S.	A. H. Allen, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1880. Swansea ...	Prof. W. Grylls Adams, M.A., F.R.S.	W. E. Ayrton, J. W. L. Glaisher, Dr. O. J. Lodge, D. MacAlister.
1881. York.........	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	Prof. W. E. Ayrton, Dr. O. J. Lodge, D. MacAlister, Rev. W. Routh.
1882. Southampton.	Rt. Hon. Lord Rayleigh, M.A., F.R.S.	W. M. Hicks, Dr. O. J. Lodge, D. MacAlister, Rev. G. Richardson.
1883. Southport	Prof. O. Henrici, Ph.D., F.R.S.	W. M. Hicks, Prof. O. J. Lodge, D. MacAlister, Prof. R. C. Rowe.
1884. Montreal ...	Prof. Sir W. Thomson, M.A., LL.D., D.C.L., F.R.S.	C. Carpmael, W. M. Hicks, A. Johnson, O. J. Lodge, D. MacAlister.
1885. Aberdeen...	Prof. G. Chrystal, M.A., F.R.S.E.	R. E. Baynes, R. T. Glazebrook, Prof. W. M. Hicks, Prof. W. Ingram.
1886. Birmingham	Prof. G. H. Darwin, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. J. H. Poynting, W. N. Shaw.

Date and Place	Presidents	Secretaries
1887. Manchester	Prof. Sir R. S. Ball, M.A., LL.D., F.R.S.	R. E. Baynes, R. T. Glazebrook, Prof. H. Lamb, W. N. Shaw.
1888. Bath………	Prof. G. F. Fitzgerald, M.A., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw.
1889. Newcastle-upon-Tyne	Capt. W. de W. Abney, C.B., R.E., F.R.S.	R. E. Baynes, R. T. Glazebrook, A. Lodge, W. N. Shaw, H. Stroud.
1890. Leeds ……	J. W. L. Glaisher, Sc.D., F.R.S., V.P.R.A.S.	R. T. Glazebrook, Prof. A. Lodge, W. N Shaw, Prof. W. Stroud.
1891. Cardiff……	Prof. O. J. Lodge, D.Sc., LL.D , F.R.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Prof. A. L. Selby.
1892. Edinburgh	Prof. A. Schuster, Ph.D., F.R.S., F.R A.S.	R. E. Baynes, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1893. Nottingham	R. T. Glazebrook, M.A., F.R.S.	W. T. A. Emtage, J. Larmor, Prof. A. Lodge, Dr. W. Peddie.
1894. Oxford ……	Prof. A. W. Rücker, M.A., F.R S.	Prof. W. H. Heaton, Prof. A. Lodge, J. Walker.
1895. Ipswich …	Prof. W. M. Hicks, M.A., F.R.S.	Prof. W. H. Heaton, Prof. A. Lodge, G. T. Walker, W. Watson.
1896. Liverpool…	Prof. J. J. Thomson, M.A , D.Sc., F.R.S.	Prof. W. H. Heaton, J. L. Howard, Prof. A. Lodge, G. T. Walker, W. Watson.
1897. Toronto …	Prof. A. R. Forsyth, M.A., F.R.S.	Prof. W. H. Heaton, J. C. Glashan, J. L. Howard, Prof. J. C. McLennan.
1898. Bristol ……	Prof. W. E. Ayrton, F.R.S. ..	A. P. Chattock, J. L Howard, C. H. Lees, W. Watson, E. T. Whittaker.
1899. Dover ……	Prof. J. H. Poynting, F.R.S.	J. L. Howard, C. H. Lees, W. Watson, E. T. Whittaker.
1900. Bradford…	Dr. J. Larmor, F.R.S.—*Dep. of Astronomy*, Dr. A. A. Common, F.R.S.	P. H. Cowell, A. Fowler, C. H. Lees, C. J. L. Wagstaffe, W. Watson, E. T. Whittaker.
1901. Glasgow …	Major P. A. MacMahon, F.R.S. —*Dep. of Astronomy*, Prof. H. H. Turner, F.R.S.	H. S. Carslaw, C H. Lees, W. Stewart, Prof. L. R. Wilberforce.
1902. Belfast……	Prof. J. Purser, LL.D., M R.I.A. —*Dep. of Astronomy*, Prof. A. Schuster, F.R.S.	H. S. Carslaw, A. R. Hinks, A. Larmor, C. H. Lees, Prof. W. B. Morton, A. W. Porter.
1903. Southport	C. Vernon Boys, F.R.S.—*Dep. of Astronomy and Meteorology*, Dr. W. N. Shaw, F.R.S	D. E. Benson, A. R. Hinks, R. W. H. T. Hudson, Dr. C. H. Lees, J. Loton, A. W. Porter.
1904. Cambridge	Prof. H. Lamb, F.R.S.—*Sub-Section of Astronomy and Cosmical Physics*, Sir J. Eliot, K.C.I.E., F.R.S.	A. R. Hinks, R. W. H. T. Hudson, Dr. C. H. Lees, Dr. W. J. S. Lockyer, A. W. Porter, W. C. D. Whetham.
1905. SouthAfrica	Prof. A. R. Forsyth, M.A., F.R S.	A. R. Hinks, S. S. Hough, R. T. A. Innes, J. H. Jeans, Dr. C. H. Lees.
1906. York………	Principal E. H. Griffiths, F.R.S.	Dr. L. N. G. Filon, Dr. J. A. Harker, A. R. Hinks, Prof. A. W. Porter, H. Dennis Taylor.
1907. Leicester…	Prof. A. E. H. Love, M.A., F.R S.	E. E. Brooks, Dr. L. N. G. Filon, Dr. J. A. Harker, A. R. Hinks, Prof. A. W. Porter.
1908. Dublin ……	Dr. W. N. Shaw, F.R.S. ……	Dr. W. G. Duffield, Dr. L. N. G. Filon, E. Gold, Prof. J. A. McClelland, Prof. A. W. Porter, Prof. E. T. Whittaker.
1909. Winnipeg	Prof. E. Rutherford, F.R.S.	Prof. F. Allen, Prof. J. C. Fields, E. Gold, F. Horton, Prof. A. W Porter, Dr. A. A. Rambaut.
1910. Sheffield …	Prof. E. W. Hobson, F.R.S.…	H. Bateman, A. S. Eddington, E. Gold, Dr. F. Horton, Dr. S. R. Milner, Prof. A. W. Porter.

Date and Place	Presidents	Secretaries
1911. Portsmouth	Prof. H. H. Turner, F.R.S. ...	H. Bateman, Prof. P. V. Bevan, A. S. Eddington, E. Gold, Prof. A. W. Porter, P. A. Yapp.

CHEMICAL SCIENCE.

COMMITTEE OF SCIENCES, II.—CHEMISTRY, MINERALOGY, &c.

Date and Place	Presidents	Secretaries
1832. Oxford......	John Dalton, D.C.L., F.R.S.	James F. W. Johnston.
1833. Cambridge	John Dalton, D.C.L., F.R.S.	Prof. Miller.
1834. Edinburgh	Dr. Hope...........................	Mr. Johnston, Dr. Christison.

SECTION B.—CHEMISTRY AND MINERALOGY.

Date and Place	Presidents	Secretaries
1835. Dublin......	Dr. T. Thomson, F.R.S.	Dr. Apjohn, Prof. Johnston.
1836. Bristol......	Rev. Prof. Cumming	Dr. Apjohn, Dr. C. Henry, W. Herapath.
1837. Liverpool...	Michael Faraday, F.R.S.......	Prof. Johnston, Prof. Miller, Dr. Reynolds.
1838. Newcastle	Rev. William Whewell, F.R.S.	Prof. Miller, H. L. Pattinson, Thomas Richardson.
1839. Birmingham	Prof. T. Graham, F.R.S.	Dr. Golding Bird, Dr. J. B. Melson.
1840. Glasgow ...	Dr. Thomas Thomson, F.R.S.	Dr. R. D. Thomson, Dr. T. Clark, Dr. L. Playfair.
1841. Plymouth...	Dr. Daubeny, F.R.S.	J. Prideaux, R. Hunt, W. M. Tweedy.
1842. Manchester	John Dalton, D.C.L., F.R.S.	Dr. L. Playfair, R. Hunt, J. Graham.
1843. Cork.........	Prof. Apjohn, M.R.I.A.........	R. Hunt, Dr. Sweeny.
1844. York.........	Prof. T. Graham, F.R.S.	Dr. L. Playfair, E. Solly, T. H. Barker.
1845. Cambridge	Rev. Prof. Cumming	R. Hunt, J. P. Joule, Prof. Miller, E. Solly.
1846. Southampton.	Michael Faraday, D.C.L., F.R.S.	Dr. Miller, R. Hunt, W. Randall.
1847. Oxford......	Rev. W. V. Harcourt, M.A., F.R.S.	B. C. Brodie, R. Hunt, Prof. Solly.
1848. Swansea ...	Richard Phillips, F.R.S.	T. H. Henry, R. Hunt, T. Williams.
1849. Birmingham	John Percy, M.D., F.R.S.......	R. Hunt, G. Shaw.
1850. Edinburgh	Dr. Christison, V.P.R.S.E. ...	Dr. Anderson, R. Hunt, Dr. Wilson.
1851. Ipswich ...	Prof. Thomas Graham, F.R.S.	T. J. Pearsall, W. S. Ward.
1852. Belfast......	Thomas Andrews, M.D., F.R.S.	Dr. Gladstone, Prof. Hodges, Prof. Ronalds.
1853. Hull	Prof. J. F. W. Johnston, M.A., F.R.S.	H. S. Blundell, Prof. R. Hunt, T. J. Pearsall.
1854. Liverpool	Prof. W. A. Miller, M.D., F.R.S.	Dr. Edwards, Dr. Gladstone, Dr. Price.
1855. Glasgow ...	Dr. Lyon Playfair, C.B., F.R.S.	Prof. Frankland, Dr. H. E. Roscoe.
1856. Cheltenham	Prof. B. C. Brodie, F.R.S. ...	J. Horsley, P. J. Worsley, Prof. Voelcker.
1857. Dublin......	Prof. Apjohn, M.D., F.R.S., M.R.I.A.	Dr. Davy, Dr. Gladstone, Prof. Sullivan.
1858. Leeds	Sir J. F. W. Herschel, Bart., D.C.L.	Dr. Gladstone, W. Odling, R. Reynolds.
1859. Aberdeen...	Dr. Lyon Playfair, C.B., F.R.S.	J. S. Brazier, Dr. Gladstone, G. D. Liveing, Dr. Odling.
1860. Oxford......	Prof. B. C. Brodie, F.R.S......	A. Vernon Harcourt, G. D. Liveing, A. B. Northcote.
1861. Manchester	Prof. W. A. Miller, M.D., F.R.S.	A. Vernon Harcourt, G. D. Liveing.
1862. Cambridge	Prof. W. H. Miller, M.A., F.R.S.	H. W. Elphinstone, W. Odling, Prof. Roscoe.

Date and Place	Presidents	Secretaries
1863. Newcastle	Dr. Alex. W. Williamson, F.R.S.	Prof. Liveing, H. L. Pattinson, J. C. Stevenson.
1864. Bath.........	W. Odling, M.B., F.R.S.......	A. V. Harcourt, Prof. Liveing, R. Biggs.
1865. Birmingham	Prof. W. A. Miller, M.D., V.P.R.S.	A. V. Harcourt, H. Adkins, Prof. Wanklyn, A. Winkler Wills.
1866. Nottingham	H. Bence Jones, M.D., F.R.S.	J. H. Atherton, Prof. Liveing, W. J. Russell, J. White.
1867. Dundee ...	Prof. T. Anderson, M.D., F.R.S.E.	A. Crum Brown, Prof. G. D. Liveing, W. J. Russell.
1868. Norwich ...	Prof. E. Frankland, F.R.S....	Dr. A. Crum Brown, Dr. W. J. Russell, F. Sutton.
1869. Exeter	Dr. H. Debus, F.R.S.	Prof. A. Crum Brown, Dr. W. J. Russell, Dr. Atkinson.
1870. Liverpool...	Prof. H. E. Roscoe, B.A., F.R.S.	Prof. A. Crum Brown, A. E. Fletcher, Dr. W. J. Russell.
1871. Edinburgh	Prof. T. Andrews, M.D., F.R.S.	J. Y. Buchanan, W. N. Hartley, T. E. Thorpe.
1872. Brighton ...	Dr. J. H. Gladstone, F.R.S....	Dr. Mills, W. Chandler Roberts, Dr. W. J. Russell, Dr. T. Wood.
1873. Bradford ...	Prof. W. J. Russell, F.R.S....	Dr. Armstrong, Dr. Mills, W. Chandler Roberts, Dr. Thorpe.
1874. Belfast......	Prof. A. Crum Brown, M.D., F.R.S.E.	Dr. T. Cranstoun Charles, W. Chandler Roberts, Prof. Thorpe.
1875. Bristol	A. G. Vernon Harcourt, M.A., F.R.S.	Dr. H. E. Armstrong, W. Chandler Roberts, W. A. Tilden.
1876. Glasgow ...	W. H. Perkin, F.R.S.	W. Dittmar, W. Chandler Roberts, J. M. Thomson, W. A. Tilden.
1877. Plymouth...	F. A. Abel, F.R.S................	Dr. Oxland, W. Chandler Roberts, J. M. Thomson.
1878. Dublin	Prof. Maxwell Simpson, M.D., F.R.S.	W. Chandler Roberts, J. M. Thomson, Dr. C. R. Tichborne, T. Wills.
1879. Sheffield ...	Prof. Dewar, M.A., F.R.S. ...	H. S. Bell, W. Chandler Roberts, J. M. Thomson.
1880. Swansea ...	Joseph Henry Gilbert, Ph.D., F.R.S.	P. P. Bedson, H. B. Dixon, W. R. E. Hodgkinson, J. M. Thomson.
1881. York.........	Prof. A. W. Williamson, F.R.S.	P. P. Bedson, H. B. Dixon, T Gough.
1882. Southampton.	Prof. G. D. Liveing, M.A., F.R.S.	P. Phillips Bedson, H. B. Dixon, J. L. Notter.
1883. Southport	Dr. J. H. Gladstone, F.R.S...	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley.
1884. Montreal ...	Prof. Sir H. E Roscoe, Ph.D., LL.D., F.R.S.	Prof. P. Phillips Bedson, H. B. Dixon, T. McFarlane, Prof. W. H. Pike.
1885. Aberdeen...	Prof. H. E. Armstrong, Ph.D., F.R.S., Sec. C.S.	Prof. P. Phillips Bedson, H. B. Dixon, H. Forster Morley, Dr. W. J. Simpson.
1886. Birmingham	W. Crookes, F.R.S., V.P.C.S.	P. P. Bedson, H. B. Dixon, H. F. Morley, W. W. J. Nicol, C. J. Woodward.
1887. Manchester	Dr. E. Schunck, F.R.S.	Prof. P. Phillips Bedson, H. Forster Morley, W. Thomson.
1888. Bath.........	Prof. W. A. Tilden, D.Sc., F.R.S., V.P.C.S.	Prof. H. B. Dixon, H. Forster Morley R. E. Moyle, W. W. J. Nicol.
1889. Newcastle-upon-Tyne	Sir I. Lowthian Bell, Bart., D.C.L., F.R.S.	H. Forster Morley, D. H. Nagel, W. W. J. Nicol, H. L. Pattinson, jun.
1890. Leeds	Prof. T. E. Thorpe, B.Sc., Ph.D., F.R.S., Treas. C.S.	C. H. Bothamley, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.
1891. Cardiff......	Prof. W. C. Roberts-Austen, C.B., F.R.S.	C. H. Bothamley, H. Forster Morley, W. W. J. Nicol, G. S. Turpin.
1892. Edinburgh	Prof. H. McLeod, F.R.S.......	J. Gibson, H. Forster Morley, D. H. Nagel, W. W. J. Nicol.

Date and Place	Presidents	Secretaries
1893. Nottingham	Prof. J. Emerson Reynolds, M.D., D.Sc., F.R.S.	J. B. Coleman, M. J. R. Dunstan, D. H. Nagel, W. W. J. Nicol.
1894. Oxford	Prof. H. B. Dixon, M.A., F.R.S.	A. Colefax, W. W. Fisher, Arthur Harden, H. Forster Morley.

SECTION B (*continued*).—CHEMISTRY.

1895. Ipswich	Prof. R. Meldola, F.R.S.	E. H. Fison, Arthur Harden, C. A. Kohn, J. W. Rodger.
1896. Liverpool	Dr. Ludwig Mond, F.R.S.	Arthur Harden, C. A. Kohn.
1897. Toronto	Prof. W. Ramsay, F.R.S.	Prof. W. H. Ellis, A. Harden, C. A. Kohn, Prof. R. F. Ruttan.
1898. Bristol	Prof. F. R. Japp, F.R.S.	C. A. Kohn, F. W. Stoddart, T. K. Rose.
1899. Dover	Horace T. Brown, F.R.S.	A. D. Hall, C. A. Kohn, T. K. Rose, Prof. W. P. Wynne.
1900. Bradford	Prof. W. H. Perkin, F.R.S.	W. M. Gardner, F. S. Kipping, W. J. Pope, T. K. Rose.
1901. Glasgow	Prof. Percy F. Frankland, F.R.S.	W. C. Anderson, G. G. Henderson, W. J. Pope, T. K. Rose.
1902. Belfast	Prof. E. Divers, F.R.S.	R. F. Blake, M. O. Forster, Prof. G. G. Henderson, Prof. W. J. Pope.
1903. Southport	Prof. W. N. Hartley, D.Sc., F.R.S.	Dr. M. O. Forster, Prof. G. G. Henderson, J. Ohm, Prof. W. J. Pope.
1904. Cambridge	Prof. Sydney Young, F.R.S.	Dr. M. O. Forster, Prof. G. G. Henderson, Dr. H. O. Jones, Prof. W. J. Pope.
1905. South Africa	George T. Beilby	W. A. Caldecott, Dr. M. O. Forster, Prof. G. G. Henderson, C. F. Juritz.
1906. York	Prof. Wyndham R. Dunstan, F.R.S.	Dr. E. F. Armstrong, Prof. A. W. Crossley, S. H. Davies, Prof. W. J. Pope.
1907. Leicester	Prof. A. Smithells, F.R.S.	Dr. E. F. Armstrong, Prof. A. W. Crossley, J. H. Hawthorn, Dr. F. M. Perkin.
1908. Dublin	Prof. F. S. Kipping, F.R.S.	Dr. E. F. Armstrong, Dr. A. McKenzie, Dr. F. M. Perkin, Dr. J. H. Pollock.
1909. Winnipeg	Prof. H. E. Armstrong, F.R.S.	Dr. E. F. Armstrong, Dr. T. M. Lowry, Dr. F. M. Perkin, J. W. Shipley.
1910. Sheffield	J. E. Stead, F.R.S.	Dr. E. F. Armstrong, Dr. T. M. Lowry, Dr. F. M. Perkin, W. E. S. Turner.
	Sub-section of Agriculture, A. D. Hall, F.R.S.	Dr. C. Crowther, J. Golding, Dr. E. J. Russell.
1911. Portsmouth	Prof. J. Walker, F.R.S.	Dr. E. F. Armstrong, Dr. C. H. Desch, Dr. T. M. Lowry, Dr. F. Beddow.

GEOLOGICAL (AND, UNTIL 1851, GEOGRAPHICAL) SCIENCE.

COMMITTEE OF SCIENCES, III.—GEOLOGY AND GEOGRAPHY.

1832. Oxford	R. I. Murchison, F.R.S.	John Taylor.
1833. Cambridge	G. B. Greenough, F.R.S.	W. Lonsdale, John Phillips.
1834. Edinburgh	Prof. Jameson	J. Phillips, T. J. Torrie, Rev. J. Yates.

SECTION C.—GEOLOGY AND GEOGRAPHY.

1835. Dublin	R. J. Griffith	Captain Portlock, T. J. Torrie.
1836. Bristol	Rev. Dr. Buckland, F.R.S.—*Geog.*, R. I. Murchison, F.R.S.	William Sanders, S. Stutchbury, T. J. Torrie.
1837. Liverpool	Rev. Prof. Sedgwick, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	Captain Portlock, R. Hunter.—*Geography*, Capt. H. M. Denham, R.N.

Date and Place	Presidents	Secretaries
1838. Newcastle.	C. Lyell, F.R.S., V.P.G.S.—*Geography*, Lord Prudhoe.	W. C. Trevelyan, Capt. Portlock.—*Geography*, Capt. Washington.
1839. Birmingham	Rev. Dr. Buckland, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	George Lloyd, M.D., H. E. Strickland, Charles Darwin.
1840. Glasgow ...	Charles Lyell, F.R.S.—*Geog.*, G. B. Greenough, F.R.S.	W. J. Hamilton, D. Milne, H. Murray, H. E. Strickland, J. Scoular.
1841. Plymouth...	H. T. De la Beche, F.R.S. ...	W. J. Hamilton, Edward Moore, M.D., R. Hutton.
1842. Manchester	R. I. Murchison, F.R.S.	E. W. Binney, R. Hutton, Dr. R. Lloyd, H. E. Strickland.
1843. Cork	Richard E. Griffith, F.R.S. ..	F. M. Jennings, H. E. Strickland.
1844. York.........	Henry Warburton, Pres. G. S.	Prof. Ansted, E. H. Bunbury.
1845. Cambridge	Rev. Prof. Sedgwick, M.A. F.R.S.	Rev. J. C. Cumming, A. C. Ramsay, Rev. W. Thorp.
1846. Southampton.	Leonard Horner, F.R.S.	Robert A. Austen, Dr. J. H. Norton, Prof. Oldham, Dr. C. T. Beke.
1847. Oxford......	Very Rev. Dr. Buckland, F.R.S.	Prof. Ansted, Prof. Oldham, A. C. Ramsay, J. Ruskin.
1848. Swansea ...	Sir H. T. De la Beche, F.R.S.	S. Benson, Prof. Oldham, Prof. Ramsay
1849. Birmingham	Sir Charles Lyell, F.R.S.......	J. B. Jukes, Prof. Oldham, A. C. Ramsay.
1850. Edinburgh[1]	Sir Roderick I. Murchison, F.R.S.	A. Keith Johnston, Hugh Miller, Prof. Nicol.

SECTION C (*continued*).—GEOLOGY.

Date and Place	Presidents	Secretaries
1851. Ipswich ...	William Hopkins, M.A., F.R.S.	C. J. F. Bunbury, G. W. Ormerod, Searles Wood.
1852. Belfast......	Lieut.-Col. Portlock, R.E., F.R.S.	James Bryce, James MacAdam, Prof. M'Coy, Prof. Nicol.
1853. Hull	Prof. Sedgwick, F.R.S.........	Prof. Harkness, William Lawton.
1854. Liverpool...	Prof. Edward Forbes, F.R.S.	John Cunningham, Prof. Harkness, G. W. Ormerod, J. W. Woodall.
1855. Glasgow ...	Sir R. I. Murchison, F.R.S....	J. Bryce, Prof. Harkness, Prof. Nicol.
1856. Cheltenham	Prof. A. C. Ramsay, F.R.S....	Rev. P. B. Brodie, Rev. R. Hepworth, Edward Hull, J. Scougall, T. Wright.
1857. Dublin	The Lord Talbot de Malahide	Prof. Harkness, G. Sanders, R. H. Scott.
1858. Leeds	William Hopkins, M.A., F.R.S.	Prof. Nicol, H. C. Sorby, E. W. Shaw.
1859. Aberdeen...	Sir Charles Lyell, LL.D., D.C.L., F.R.S.	Prof. Harkness, Rev. J. Longmuir, H. C. Sorby.
1860. Oxford	Rev. Prof. Sedgwick, F.R.S...	Prof. Harkness, E. Hull, J. W. Woodall.
1861. Manchester	Sir R. I. Murchison, D.C.L., LL.D., F.R.S.	Prof. Harkness, Edward Hull, T. Rupert Jones, G. W. Ormerod.
1862. Cambridge	J. Beete Jukes, M.A., F.R.S.	Lucas Barrett, Prof. T. Rupert Jones, H. C. Sorby.
1863. Newcastle	Prof. Warington W. Smyth, F.R.S., F.G.S.	E. F. Boyd, John Daglish, H. C. Sorby, Thomas Sopwith.
1864. Bath.........	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	W. B. Dawkins, J. Johnston, H. C. Sorby, W. Pengelly.
1865. Birmingham	Sir R. I. Murchison, Bart., K.C.B., F.R.S.	Rev. P. B. Brodie, J. Jones, Rev. E. Myers, H. C. Sorby, W. Pengelly.
1866. Nottingham	Prof. A. C. Ramsay, LL.D., F.R.S.	R. Etheridge, W. Pengelly, T. Wilson, G. H. Wright.
1867. Dundee ...	Archibald Geikie, F.R.S.......	E. Hull, W. Pengelly, H. Woodward.

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[1] Geography was constituted a separate Section, see page lxxx.

Date and Place	Presidents	Secretaries
1868. Norwich	R. A. C. Godwin-Austen, F.R.S., F.G.S.	Rev. O. Fisher, Rev. J. Gunn, W. Pengelly, Rev. H. H. Winwood.
1869. Exeter	Prof. R. Harkness, F.R.S., F.G.S.	W. Pengelly, W. Boyd Dawkins, Rev. H. H. Winwood.
1870. Liverpool	Sir Philip de M. Grey Egerton, Bart., M.P., F.R.S.	W. Pengelly, Rev. H. H. Winwood, W. Boyd Dawkins, G. H. Morton.
1871. Edinburgh	Prof. A. Geikie, F.R.S., F.G.S.	R. Etheridge, J. Geikie, T. McKenny Hughes, L. C. Miall.
1872. Brighton	R. A. C. Godwin-Austen, F.R.S., F.G.S.	L. C. Miall, George Scott, William Topley, Henry Woodward.
1873. Bradford	Prof. J. Phillips, F.R.S.	L. C. Miall, R. H. Tiddeman, W. Topley.
1874. Belfast	Prof. Hull, M.A., F.R.S., F.G.S.	F. Drew, L. C. Miall, R. G. Symes, R. H. Tiddeman.
1875. Bristol	Dr. T. Wright, F.R.S.E., F.G.S.	L. C. Miall, E. B. Tawney, W. Topley.
1876. Glasgow	Prof. John Young, M.D.	J. Armstrong, F. W. Rudler, W. Topley.
1877. Plymouth	W. Pengelly, F.R.S., F.G.S.	Dr. Le Neve Foster, R. H. Tiddeman, W. Topley.
1878. Dublin	John Evans, D.C.L., F.R.S., F.S.A., F.G.S.	E. T. Hardman, Prof. J. O'Reilly, R. H. Tiddeman.
1879. Sheffield	Prof. P. M. Duncan, F.R.S.	W. Topley, G. Blake Walker.
1880. Swansea	H. C. Sorby, F.R.S., F.G.S.	W. Topley, W. Whitaker.
1881. York	A. C. Ramsay, LL.D., F.R.S., F.G.S.	J. E. Clark, W. Keeping, W. Topley, W. Whitaker.
1882. Southampton.	R. Etheridge, F.R.S., F.G.S.	T. W. Shore, W. Topley, E. Westlake, W. Whitaker.
1883. Southport	Prof. W. C. Williamson, LL.D., F.R.S.	R. Betley, C. E. De Rance, W. Topley, W. Whitaker.
1884. Montreal	W. T. Blanford, F.R.S., Sec. G.S.	F. Adams, Prof. E. W. Claypole, W. Topley, W. Whitaker.
1885. Aberdeen	Prof. J. W. Judd, F.R.S., Sec. G.S.	C. E. De Rance, J. Horne, J. J. H. Teall, W. Topley.
1886. Birmingham	Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.	W. J. Harrison, J. J. H. Teall, W. Topley, W. W. Watts.
1887. Manchester	Henry Woodward, LL.D., F.R.S., F.G.S.	J. E. Marr, J. J. H. Teall, W. Topley, W. W. Watts.
1888. Bath	Prof. W. Boyd Dawkins, M.A., F.R.S., F.G.S.	Prof. G. A. Lebour, W. Topley, W. W. Watts, H. B. Woodward.
1889. Newcastle-upon-Tyne	Prof. J. Geikie, LL.D., D.C.L., F.R.S., F.G.S.	Prof. G. A. Lebour, J. E. Marr, W. W. Watts, H. B. Woodward.
1890. Leeds	Prof. A. H. Green, M.A., F.R.S., F.G.S.	J. E. Bedford, Dr. F. H. Hatch, J. E. Marr, W. W. Watts.
1891. Cardiff	Prof. T. Rupert Jones, F.R.S., F.G.S.	W. Galloway, J. E. Marr, Clement Reid, W. W. Watts.
1892. Edinburgh	Prof. C. Lapworth, LL.D., F.R.S., F.G.S.	H. M. Cadell, J. E. Marr, Clement Reid, W. W. Watts.
1893. Nottingham	J. J. H. Teall, M.A., F.R.S., F.G.S.	J. W. Carr, J. E. Marr, Clement Reid, W. W. Watts.
1894. Oxford	L. Fletcher, M.A., F.R.S.	F. A. Bather, A. Harker, Clement Reid, W. W. Watts.
1895. Ipswich	W. Whitaker, B.A., F.R.S.	F. A. Bather, G. W. Lamplugh, H. A. Miers, Clement Reid.
1896. Liverpool	J. E. Marr, M.A., F.R.S.	J. Lomas, Prof. H. A. Miers, C. Reid.
1897. Toronto	Dr. G. M. Dawson, C.M.G., F.R.S.	Prof. A. P. Coleman, G. W. Lamplugh, Prof. H. A. Miers.
1898. Bristol	W. H. Hudleston, F.R.S.	G. W. Lamplugh, Prof. H. A. Miers, H. Pentecost.
1899. Dover	Sir Archibald Geikie, F.R.S.	J. W. Gregory, G. W. Lamplugh, Capt. McDakin, Prof. H. A. Miers.

Date and Place	Presidents	Secretaries
1900. Bradford ...	Prof. W. J. Sollas, F.R.S. ...	H. L. Bowman, Rev. W. L. Carter, G. W. Lamplugh, H. W. Monckton.
1901. Glasgow ...	John Horne, F.R.S.	H. L. Bowman, H. W. Monckton
1902. Belfast......	Lieut.-Gen. C. A. McMahon, F.R.S.	H. L. Bowman, H. W. Monckton, J. St. J. Phillips, H. J. Seymour.
1903. Southport	Prof. W. W. Watts, M.A., M.Sc.	H. L. Bowman, Rev. W. L. Carter, J. Lomas, H. W. Monckton
1904. Cambridge	Aubrey Strahan, F.R.S.	H. L. Bowman, Rev. W. L. Carter, J. Lomas, H. Woods.
1905. SouthAfrica	Prof. H. A. Miers, M.A., D.Sc., F.R.S.	H. L. Bowman, J. Lomas, Dr. Molengraaff, Prof. A. Young, Prof. R. B. Young.
1906. York.........	G. W. Lamplugh, F.R.S.	H. L. Bowman, Rev. W. L. Carter, Rev. W. Johnson, J. Lomas.
1907. Leicester...	Prof. J. W. Gregory, F.R.S. ...	Dr. F. W. Bennett, Rev. W. L. Carter, Prof. T. Groom, J. Lomas.
1908. Dublin......	Prof. John Joly, F.R.S.	Rev. W. L. Carter, J. Lomas, Prof. S. H. Reynolds, H. J. Seymour.
1909. Winnipeg...	Dr. A. Smith Woodward, F.R.S.	W. L. Carter, Dr. A. R. Dwerryhouse, R. T. Hodgson, Prof. S. H. Reynolds.
1910. Sheffield ...	Prof. A. P. Coleman, F.R.S...	W. L. Carter, Dr. A. R. Dwerryhouse, B. Hobson, Prof. S. H. Reynolds.
1911. Portsmouth	A. Harker, F.R.S.	Col. C. W. Bevis, W. L. Carter, Dr. A. R. Dwerryhouse, Prof. S. H. Reynolds.

BIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, IV.—ZOOLOGY, BOTANY, PHYSIOLOGY, ANATOMY.

Date and Place	Presidents	Secretaries
1832. Oxford......	Rev. P. B. Duncan, F.G.S. ...	Rev. Prof. J. S. Henslow.
1833. Cambridge[1]	Rev. W. L. P. Garnons, F.L.S.	C. C. Babington, D. Don.
1834. Edinburgh	Prof. Graham....................	W. Yarrell, Prof. Burnett.

SECTION D.—ZOOLOGY AND BOTANY.

Date and Place	Presidents	Secretaries
1835. Dublin......	Dr. Allman........................	J. Curtis, Dr. Litton.
1836. Bristol......	Rev. Prof. Henslow	J. Curtis, Prof. Don, Dr. Riley, S. Rootsey.
1837. Liverpool...	W. S. MacLeay..................	C. C. Babington, Rev. L. Jenyns, W. Swainson.
1838. Newcastle	Sir W. Jardine, Bart.	J. E. Gray, Prof. Jones, R. Owen, Dr. Richardson.
1839. Birmingham	Prof. Owen, F.R.S.	E. Forbes, W. Ick, R. Patterson.
1840. Glasgow ...	Sir W. J. Hooker, LL.D.......	Prof. W. Couper, E. Forbes, R. Patterson.
1841. Plymouth...	John Richardson, M.D., F.R.S.	J. Couch, Dr. Lankester, R. Patterson.
1842. Manchester	Hon. and Very Rev. W. Herbert, LL.D., F.L.S.	Dr. Lankester, R. Patterson, J. A. Turner.
1843. Cork.........	William Thompson, F.L.S....	G. J. Allman, Dr. Lankester, R. Patterson.
1844. York.........	Very Rev. the Dean of Manchester.	Prof. Allman, H. Goodsir, Dr. King, Dr. Lankester.
1845. Cambridge	Rev. Prof. Henslow, F.L.S....	Dr. Lankester, T. V. Wollaston.
1846. Southampton.	Sir J. Richardson, M.D., F.R.S.	Dr. Lankester, T. V. Wollaston, H. Wooldridge.
1847. Oxford......	H. E. Strickland, M.A., F.R.S.	Dr. Lankester, Dr. Melville, T. V. Wollaston.

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[1] At this Meeting Physiology and Anatomy were made a separate Committee, for Presidents and Secretaries of which see p. lxxix.

SECTION D (*continued*).—ZOOLOGY AND BOTANY, INCLUDING PHYSIOLOGY.

[For the Presidents and Secretaries of the Anatomical and Physiological Subsections and the temporary Section E of Anatomy and Medicine, see p. lxxix.]

Date and Place	Presidents	Secretaries
1848. Swansea	L. W. Dillwyn, F.R.S.	Dr. R. Wilbraham Falconer, A. Henfrey, Dr. Lankester.
1849. Birmingham	William Spence, F.R.S.	Dr. Lankester, Dr. Russell.
1850. Edinburgh	Prof. Goodsir, F.R.S., F.R.S.E.	Prof. J. H. Bennett, M.D., Dr. Lankester, Dr. Douglas Maclagan.
1851. Ipswich	Rev. Prof. Henslow, M.A., F.R.S.	Prof. Allman, F. W. Johnston, Dr. E. Lankester.
1852. Belfast	W. Ogilby	Dr. Dickie, George C. Hyndman, Dr. Edwin Lankester.
1853. Hull	C. C. Babington, M.A., F.R.S.	Robert Harrison, Dr. E. Lankester.
1854. Liverpool	Prof. Balfour, M.D., F.R.S.	Isaac Byerley, Dr. E. Lankester.
1855. Glasgow	Rev. Dr. Fleeming, F.R.S.E.	William Keddie, Dr. E. Lankester.
1856. Cheltenham	Thomas Bell, F.R.S., Pres. L.S.	Dr. J. Abercrombie, Prof. Buckman, Dr. E. Lankester.
1857. Dublin	Prof. W. H. Harvey, M.D., F.R.S.	Prof. J. R. Kinahan, Dr. E. Lankester, Robert Patterson, Dr. W. E. Steele.
1858. Leeds	C. C. Babington, M.A., F.R.S.	Henry Denny, Dr. Heaton, Dr. E. Lankester, Dr. E. Perceval Wright.
1859. Aberdeen	Sir W. Jardine, Bart., F.R.S.E.	Prof. Dickie, M.D., Dr. E. Lankester, Dr. Ogilvy.
1860. Oxford	Rev. Prof. Henslow, F.L.S.	W. S. Church, Dr. E. Lankester, P. L. Sclater, Dr. E. Perceval Wright.
1861. Manchester	Prof. C. C. Babington, F.R.S.	Dr. T. Alcock, Dr. E. Lankester, Dr. P. L. Sclater, Dr. E. P. Wright.
1862. Cambridge	Prof. Huxley, F.R.S.	Alfred Newton, Dr. E. P. Wright.
1863. Newcastle	Prof. Balfour, M.D., F.R.S.	Dr. E. Charlton, A. Newton, Rev. H. B. Tristram, Dr. E. P. Wright.
1864. Bath	Dr. John E. Gray, F.R.S.	H. B. Brady, C. E. Broom, H. T. Stainton, Dr. E. P. Wright.
1865. Birmingham.[1]	T. Thomson, M.D., F.R.S.	Dr. J. Anthony, Rev. C. Clarke, Rev. H. B. Tristram, Dr. E. P. Wright.

SECTION D (*continued*).—BIOLOGY.

Date and Place	Presidents	Secretaries
1866. Nottingham	Prof. Huxley, F.R.S.—*Dep. of Physiol.*, Prof. Humphry, F.R.S.—*Dep. of Anthropol.*, A. R. Wallace.	Dr. J. Beddard, W. Felkin, Rev. H. B. Tristram, W. Turner, E. B. Tylor, Dr. E. P. Wright.
1867. Dundee	Prof. Sharpey, M.D., Sec. R.S.—*Dep. of Zool. and Bot.*, George Busk, M.D., F.R.S.	C. Spence Bate, Dr. S. Cobbold, Dr. M. Foster, H. T. Stainton, Rev. H. B. Tristram, Prof. W. Turner.
1868. Norwich	Rev. M. J. Berkeley, F.L.S.—*Dep. of Physiology*, W. H. Flower, F.R.S.	Dr. T. S. Cobbold, G. W. Firth, Dr. M. Foster, Prof. Lawson, H. T. Stainton, Rev. Dr. H. B. Tristram, Dr. E. P. Wright.
1869. Exeter	George Busk, F.R.S., F.L.S.—*Dep. of Bot. and Zool.*, C. Spence Bate, F.R.S.—*Dep. of Ethno.*, E. B. Tylor.	Dr. T. S. Cobbold, Prof. M. Foster, E. Ray Lankester, Prof. Lawson, H. T. Stainton, Rev. H. B. Tristram.
1870. Liverpool	Prof. G. Rolleston, M.A., M.D., F.R.S., F.L.S.—*Dep. of Anat. and Physiol.*, Prof. M. Foster, M.D., F.L.S.—*Dep. of Ethno.*, J. Evans, F.R.S.	Dr. T. S. Cobbold, Sebastian Evans, Prof. Lawson, Thos. J. Moore, H. T. Stainton, Rev. H. B. Tristram, C. Staniland Wake, E. Ray Lankester.

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[1] The title of Section D was changed to Biology.

Date and Place	Presidents	Secretaries
1871. Edinburgh	Prof. Allen Thomson, M.D., F.R.S.—*Dep. of Bot. and Zool.*, Prof. Wyville Thomson, F.R.S.—*Dep. of Anthropol.*, Prof. W. Turner, M.D.	Dr. T. R. Fraser, Dr. Arthur Gamgee, E. Ray Lankester, Prof. Lawson, H. T. Stainton, C. Staniland Wake, Dr. W. Rutherford, Dr. Kelburne King.
1872. Brighton ...	Sir J. Lubbock, Bart., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Burdon Sanderson, F.R.S.—*Dep. of Anthropol.*, Col. A. Lane Fox, F.G.S.	Prof. Thiselton-Dyer, H. T. Stainton, Prof. Lawson, F. W. Rudler, J. H. Lamprey, Dr. Gamgee, E. Ray Lankester, Dr. Pye-Smith.
1873. Bradford ...	Prof. Allman, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Rutherford, M.D.—*Dep. of Anthropol.*, Dr. Beddoe, F.R.S.	Prof. Thiselton-Dyer, Prof. Lawson, R. M'Lachlan, Dr. Pye-Smith, E. Ray Lankester, F. W. Rudler, J. H. Lamprey.
1874. Belfast	Prof. Redfern, M.D.—*Dep. of Zool. and Bot.*, Dr. Hooker, C.B., Pres. R.S.—*Dep. of Anthrop.*, Sir W. R. Wilde, M.D.	W. T. Thiselton-Dyer, R. O. Cunningham, Dr. J. J. Charles, Dr. P. H. Pye-Smith, J. J. Murphy, F. W. Rudler.
1875. Bristol	P. L. Sclater, F.R.S.—*Dep of Anat. and Physiol.*, Prof. Cleland, F.R.S.—*Dep. of Anth.*, Prof. Rolleston, F.R.S.	E. R. Alston, Dr. McKendrick, Prof. W. R. M'Nab, Dr. Martyn, F. W. Rudler, Dr. P. H. Pye-Smith, Dr. W. Spencer.
1876. Glasgow ...	A. Russel Wallace, F.L.S.—*Dep. of Zool. and Bot.*, Prof. A. Newton, F.R.S.—*Dep. of Anat. and Physiol.*, Dr. J. G. McKendrick.	E. R. Alston, Hyde Clarke, Dr. Knox, Prof. W. R. M'Nab, Dr. Muirhead, Prof. Morrison Watson.
1877. Plymouth...	J. Gwyn Jeffreys, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. Macalister.—*Dep. of Anthropol.*, F. Galton, F.R.S.	E. R. Alston, F. Brent, Dr. D. J. Cunningham, Dr. C. A. Hingston, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler.
1878. Dublin	Prof. W. H. Flower, F.R.S.—*Dep. of Anthropol.*, Prof. Huxley, Sec. R.S.—*Dep. of Anat. and Physiol.*, R. McDonnell, M.D., F.R.S.	Dr. R. J. Harvey, Dr. T. Hayden, Prof. W. R. M'Nab, Prof. J. M. Purser, J. B. Rowe, F. W. Rudler.
1879. Sheffield ...	Prof. St. George Mivart, F.R.S.—*Dep. of Anthropol.*, E. B. Tylor, D.C.L., F.R.S.—*Dep. of Anat. and Physiol.*, Dr. Pye-Smith.	Arthur Jackson, Prof. W. R. M'Nab, J. B. Rowe, F. W. Rudler, Prof. Schäfer.
1880. Swansea ...	A. C. L. Günther, F.R.S.—*Dep. of Anat. & Physiol.*, F. M. Balfour, F.R.S.—*Dep. of Anthropol.*, F. W. Rudler.	G. W. Bloxam, John Priestley, Howard Saunders, Adam Sedgwick.
1881. York.........	R. Owen, F.R.S.—*Dep. of Anthropol.*, Prof. W. H. Flower, F.R.S.—*Dep. of Anat. and Physiol.*, Prof. J. S. Burdon Sanderson, F.R.S.	G. W. Bloxam, W. A. Forbes, Rev. W. C. Hey, Prof. W. R. M'Nab, W. North, John Priestley, Howard Saunders, H. E. Spencer.
1882. Southampton.	Prof. A. Gamgee, M.D., F.R.S.—*Dep. of Zool. and Bot.*, Prof. M. A. Lawson, F.L.S.—*Dep. of Anthropol.*, Prof. W. Boyd Dawkins, F.R.S.	G. W. Bloxam, W. Heape, J. B. Nias, Howard Saunders, A. Sedgwick, T. W. Shore, jun.
1883. Southport	Prof. E. Ray Lankester, M.A., F.R.S.—*Dep. of Anthropol.*, W. Pengelly, F.R.S.	G. W. Bloxam, Dr. G. J. Haslam, W. Heape, W. Hurst, Prof. A. M. Marshall, Howard Saunders, Dr. G. A. Woods.

Date and Place	Presidents	Secretaries
1884. Montreal[1]...	Prof. H. N. Moseley, M.A., F.R.S.	Prof. W. Osler, Howard Saunders, A. Sedgwick, Prof. R. R. Wright.
1885. Aberdeen...	Prof. W. C. M'Intosh, M.D., LL.D., F.R.S., F.R.S.E.	W. Heape, J. McGregor-Robertson, J. Duncan Matthews, Howard Saunders, H. Marshall Ward.
1886. Birmingham	W. Carruthers, Pres. L.S., F.R.S., F.G.S.	Prof. T. W. Bridge, W. Heape, Prof. W. Hillhouse, W. L. Sclater, Prof. H. Marshall Ward.
1887. Manchester	Prof. A. Newton, M.A., F R S., F.L.S., V.P.Z S.	C. Bailey, F. E. Beddard, S. F. Harmer, W. Heape, W. L. Sclater, Prof. H. Marshall Ward.
1888. Bath.........	W. T. Thiselton-Dyer, C.M.G., F.R.S , F.L.S.	F. E. Beddard, S. F. Harmer, Prof. H. Marshall Ward, W. Gardiner. Prof. W. D. Halliburton.
1889. Newcastle-upon Tyne	Prof. J. S. Burdon Sanderson, M.A., M D., F.R.S.	C. Bailey, F. E. Beddard, S. F. Harmer, Prof. T. Oliver, Prof. H. Marshall Ward.
1890. Leeds	Prof. A. Milnes Marshall, M A., M.D., D.Sc., F.R.S.	S. F. Harmer, Prof. W. A. Herdman, S. J. Hickson, F. W. Oliver H. Wager, H. Marshall Ward.
1891. Cardiff.....	Francis Darwin, M.A., M.B., F.R.S., F.L.S.	F. E. Beddard, Prof. W. A. Herdman, Dr. S. J. Hickson, G. Murray, Prof. W. N. Parker, H. Wager.
1892. Edinburgh	Prof. W. Rutherford, M.D., F.R S., F.R.S.E.	G. Brook, Prof W. A. Herdman, G. Murray, W. Stirling, H. Wager.
1893. Nottingham[2]	Rev Canon H. B. Tristram, M.A., LL.D , F.R.S.	G. C. Bourne, J. B. Farmer, Prof. W. A. Herdman, S. J. Hickson, W. B. Ransom, W. L. Sclater.
1894. Oxford[3] ...	Prof I. Bayley Balfour, M A., F.R.S	W. W. Benham, Prof. J. B. Farmer, Prof. W A. Herdman, Prof. S. J. Hickson, G. Murray, W. L. Sclater.

SECTION D (*continued*).—ZOOLOGY.

Date and Place	Presidents	Secretaries
1895. Ipswich ...	Prof. W. A. Herdman, F.R S.	G. C. Bourne, H. Brown, W. E. Hoyle, W. L. Sclater.
1896. Liverpool...	Prof. E. B. Poulton, F.R.S. ...	H O. Forbes, W. Garstang, W. E. Hoyle.
1897. Toronto ...	Prof. L. C. Miall, F.R.S.	W. Garstang, W. E. Hoyle, Prof. E. E. Prince.
1898. Bristol.	Prof. W. F. R. Weldon, F.R.S.	Prof. R Boyce, W. Garstang, Dr. A. J. Harrison, W. E. Hoyle.
1899. Dover	Adam Sedgwick, F.R.S.	W. Garstang, J Graham Kerr.
1900 Bradford...	Dr. R. H. Traquair, F.R.S. ...	W. Garstang, J. G. Kerr, T. H. Taylor, Swale Vincent.
1901. Glasgow ...	Prof. J. Cossar Ewart, F.R.S.	J. G. Kerr, J. Rankin, J. Y. Simpson.
1902. Belfast......	Prof. G. B. Howes, F.R.S. ...	Prof. J. G. Kerr, R. Patterson, J. Y. Simpson.
1903. Southport	Prof. S. J. Hickson, F.R.S. ...	Dr. J. H. Ashworth, J. Barcroft, A. Quayle, Dr. J. Y. Simpson, Dr. H. W. M. Tims.
1904. Cambridge	William Bateson, F.R S.	Dr. J H. Ashworth, L. Doncaster, Prof. J. Y. Simpson, Dr. H. W. M. Tims.
1905. South Africa	G. A. Boulenger, F.R.S.	Dr. Pakes, Dr. Purcell, Dr. H. W. M. Tims, Prof. J. Y. Simpson.

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[1] Anthropology was made a separate Section, see p. lxxxvii.
[2] Physiology was made a separate Section, see p. lxxxviii.
[3] The title of Section D was changed to Zoology.

Date and Place	Presidents	Secretaries
1906. York	J. J. Lister, F.R.S.	Dr. J. H. Ashworth, L. Doncaster, Oxley Grabham, Dr. H. W. M. Tims.
1907. Leicester	Dr. W. E. Hoyle, M.A.	Dr. J. H. Ashworth, L Doncaster, E. E. Lowe, Dr. H. W. M. Tims
1908. Dublin	Dr. S. F. Harmer, F.R.S.	Dr. J. H. Ashworth, L. Doncaster, Prof. A. Fraser, Dr. H. W. M. Tims.
1909. Winnipeg	Dr. A. E. Shipley, F.R.S.	C. A. Baragar, C. L. Boulenger, Dr. J. Pearson, Dr. H. W. M. Tims.
1910. Sheffield	Prof. G. C. Bourne, F.R.S.	Dr. J. H. Ashworth, L. Doncaster, T. J. Evans, Dr. H. W. M. Tims.
1911. Portsmouth	Prof. D'Arcy W. Thompson, C.B.	Dr. J. H. Ashworth, C. Foran, R. D. Laurie, Dr. H. W. M. Tims.

ANATOMICAL AND PHYSIOLOGICAL SCIENCES.

COMMITTEE OF SCIENCES, V.—ANATOMY AND PHYSIOLOGY.

1833. Cambridge	Dr. J. Haviland	Dr. H. J. H Bond, Mr. G. E. Paget.
1834. Edinburgh	Dr. Abercrombie	Dr. Roget, Dr. William Thomson.

SECTION E (UNTIL 1847).—ANATOMY AND MEDICINE.

1835. Dublin	Dr. J. C. Pritchard	Dr. Harrison, Dr. Hart.
1836. Bristol	Dr. P. M. Roget, F.R.S.	Dr. Symonds.
1837. Liverpool	Prof. W. Clark, M.D.	Dr. J. Carson, jun., James Long, Dr. J. R. W. Vose.
1838. Newcastle	T. E. Headlam, M.D.	T. M. Greenhow, Dr. J. R. W. Vose.
1839. Birmingham	John Yelloly, M.D., F.R.S.	Dr. G. O. Rees, F. Ryland.
1840. Glasgow	James Watson, M.D.	Dr. J. Brown, Prof. Couper, Prof Reid.

SECTION E.—PHYSIOLOGY.

1841. Plymouth	P. M. Roget, M.D., Sec. R.S.	J. Butter, J. Fuge, Dr. R. S. Sargent.
1842. Manchester	Edward Holme, M.D., F.L.S.	Dr. Chaytor, Dr. R. S. Sargent.
1843. Cork	Sir James Pitcairn, M.D.	Dr. John Popham, Dr. R. S. Sargent.
1844. York	J. C. Pritchard, M.D.	I. Erichsen, Dr. R. S. Sargent.
1845. Cambridge	Prof. J. Haviland, M.D.	Dr. R. S. Sargent, Dr. Webster.
1846. Southampton.	Prof. Owen, M.D., F.R.S.	C. P. Keele, Dr. Laycock, Dr. Sargent.
1847. Oxford[1]	Prof. Ogle, M.D., F.R.S.	T. K. Chambers, W. P. Ormerod.

PHYSIOLOGICAL SUB-SECTIONS OF SECTION D.

1850. Edinburgh	Prof. Bennett, M.D., F.R.S.E.	
1855. Glasgow	Prof. Allen Thomson, F.R.S.	Prof. J. H. Corbett, Dr. J. Struthers.
1857. Dublin	Prof. R. Harrison, M.D.	Dr. R. D. Lyons, Prof. Redfern.
1858. Leeds	Sir B. Brodie, Bart., F.R.S.	C. G. Wheelhouse.
1859. Aberdeen	Prof. Sharpey, M.D., Sec. R.S.	Prof. Bennett, Prof. Redfern.
1860. Oxford	Prof. G. Rolleston, M.D., F.L.S.	Dr. R. M'Donnell, Dr. Edward Smith.
1861. Manchester	Dr. John Davy, F.R.S.	Dr. W. Roberts, Dr. Edward Smith.
1862. Cambridge	G. E. Paget, M.D.	G. F. Helm, Dr. Edward Smith.
1863. Newcastle	Prof. Rolleston, M.D., F.R.S.	Dr. D. Embleton, Dr. W. Turner.
1864. Bath	Dr. Edward Smith, F.R.S.	J. S. Bartrum, Dr. W. Turner.
1865. Birmingham.[2]	Prof. Acland, M.D., LL.D., F.R.S.	Dr. A. Fleming, Dr. P. Heslop, Oliver Pembleton, Dr. W. Turner.

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[1] Sections D and E were incorporated under the title of 'Section D—Zoology and Botany, including Physiology' (see p. lxxv). Section E, being then vacant, was assigned in 1851 to Geography.

[2] Vide note on page lxxv.

GEOGRAPHICAL AND ETHNOLOGICAL SCIENCES.

[For Presidents and Secretaries for Geography previous to 1851, see Section C, p. lxxii.]

ETHNOLOGICAL SUB-SECTIONS OF SECTION D.

Date and Place	Presidents	Secretaries
1846. Southampton	Dr. J. C. Pritchard	Dr. King.
1847. Oxford	Prof. H. H. Wilson, M.A.	Prof. Buckley.
1848. Swansea		G. Grant Francis.
1849. Birmingham		Dr. R. G. Latham.
1850. Edinburgh	Vice-Admiral Sir A. Malcolm	Daniel Wilson.

SECTION E.—GEOGRAPHY AND ETHNOLOGY.

Date and Place	Presidents	Secretaries
1851. Ipswich	Sir R. I. Murchison, F.R.S., Pres. R.G.S.	R. Cull, Rev. J. W. Donaldson, Dr. Norton Shaw.
1852. Belfast	Col. Chesney, R.A., D.C.L., F.R.S.	R. Cull, E. MacAdam, Dr. Norton Shaw.
1853. Hull	R. G. Latham, M.D., F.R.S.	R. Cull, Rev. H. W. Kemp, Dr. Norton Shaw.
1854. Liverpool	Sir R. I. Murchison, D.C.L., F.R.S.	Richard Cull, Rev. H. Higgins, Dr. Ihne, Dr. Norton Shaw.
1855. Glasgow	Sir J. Richardson, M.D., F.R.S.	Dr. W. G. Blackie, R. Cull, Dr. Norton Shaw.
1856. Cheltenham	Col. Sir H. C. Rawlinson, K.C.B.	R. Cull, F. D. Hartland, W. H. Rumsey, Dr. Norton Shaw.
1857. Dublin	Rev. Dr. J. Henthorn Todd, Pres. R.I.A.	R. Cull, S. Ferguson. Dr. R. R. Madden, Dr. Norton Shaw.
1858. Leeds	Sir R. I. Murchison, G.C.St.S., F.R.S.	R. Cull, F. Galton, P. O'Callaghan, Dr. Norton Shaw, T. Wright.
1859. Aberdeen	Rear-Admiral Sir James Clerk Ross, D.C.L., F.R.S.	Richard Cull, Prof. Geddes, Dr. Norton Shaw.
1860. Oxford	Sir R. I. Murchison, D.C.L., F.R.S.	Capt. Burrows, Dr. J. Hunt, Dr. C. Lemprière, Dr. Norton Shaw.
1861. Manchester	John Crawfurd, F.R.S.	Dr. J. Hunt, J. Kingsley, Dr. Norton Shaw, W. Spottiswoode.
1862. Cambridge	Francis Galton, F.R.S.	J. W. Clarke, Rev. J. Glover, Dr. Hunt, Dr. Norton Shaw, T. Wright.
1863. Newcastle	Sir R. I. Murchison, K.C.B., F.R.S.	C. Carter Blake, Hume Greenfield, C. R. Markham, R. S. Watson.
1864. Bath	Sir R. I. Murchison, K.C.B., F.R.S.	H. W. Bates, C. R. Markham, Capt. R. M. Murchison, T. Wright.
1865. Birmingham.	Major-General Sir H. Rawlinson, M.P., K.C.B., F.R.S.	H. W. Bates, S. Evans, G. Jabet, C. R. Markham, Thomas Wright.
1866. Nottingham	Sir Charles Nicholson, Bart., LL.D.	H. W. Bates, Rev. E. T. Cusins, R. H. Major, Clements R. Markham, D. W. Nash, T. Wright.
1867. Dundee	Sir Samuel Baker, F.R.G.S.	H. W. Bates, Cyril Graham, C. R. Markham, S. J. Mackie, R. Sturrock.
1868. Norwich	Capt. G. H. Richards, R.N., F.R.S.	T. Baines, H. W. Bates, Clements R. Markham, T. Wright.

SECTION E (*continued*).—GEOGRAPHY.

Date and Place	Presidents	Secretaries
1869. Exeter	Sir Bartle Frere, K.C.B., LL.D., F.R.G.S.	H. W. Bates, Clements R. Markham, J. H. Thomas.
1870. Liverpool	Sir R. I. Murchison, Bt., K.C.B., LL.D., D.C.L., F.R.S., F.G.S.	H. W. Bates, David Buxton, Albert J. Mott, Clements R. Markham.
1871. Edinburgh	Colonel Yule, C.B., F.R.G.S.	A. Buchan, A. Keith Johnston, Clements R. Markham, J. H. Thomas,

Date and Place	Presidents	Secretaries
1872. Brighton ...	Francis Galton, F.R.S.	H. W. Bates, A. Keith Johnston, Rev. J. Newton, J. H. Thomas.
1873. Bradford ...	Sir Rutherford Alcock, K.C.B.	H. W. Bates, A. Keith Johnston, Clements R. Markham.
1874. Belfast......	Major Wilson, R.E., F.R.S., F.R.G.S.	E. G. Ravenstein, E. C. Rye, J. H. Thomas.
1875. Bristol......	Lieut.-General Strachey, C.S.I., R.E., F.R.S., F.R.G.S.	H. W. Bates, E. C. Rye, F. F. Tuckett.
1876. Glasgow ...	Capt. Evans, C.B., F.R.S.	H. W. Bates, E. C. Rye, R. O. Wood.
1877. Plymouth...	Adm. Sir E. Ommanney, C.B.	H. W. Bates, F. E. Fox, E. C. Rye.
1878. Dublin......	Prof. Sir C. Wyville Thomson, LL.D., F.R.S., F.R.S.E.	John Coles, E. C. Rye.
1879. Sheffield ...	Clements R. Markham, C.B., F.R.S., Sec. R.G.S.	H. W. Bates, C. E. D. Black, E. C. Rye.
1880. Swansea ...	Lieut.-Gen. Sir J H. Lefroy, C.B., K.C.M.G., R.A., F.R.S.	H. W. Bates, E. C. Rye.
1881. York.......	Sir J. D. Hooker, K.C.S.I., C.B., F.R.S.	J. W. Barry, H. W. Bates.
1882. Southampton.	Sir R. Temple, Bart., G.C.S.I., F.R.G.S.	E. G. Ravenstein, E. C. Rye.
1883. Southport...	Lieut.-Col. H. H. Godwin-Austen, F.R.S.	John Coles, E. G. Ravenstein, E. C. Rye.
1884. Montreal ...	Gen. Sir J. H. Lefroy, C.B., K.C.M.G., F.R.S., V.P.R G.S.	Rev. Abbé Laflamme, J. S. O'Halloran, E. G. Ravenstein, J. F. Torrance.
1885. Aberdeen...	Gen. J. T. Walker, C.B., R.E., LL.D., F.R.S.	J. S. Keltie, J. S. O'Halloran, E. G. Ravenstein, Rev. G. A. Smith.
1886. Birmingham.	Maj.-Gen. Sir. F. J. Goldsmid, K.C.S.I., C.B., F.R.G.S.	F. T. S. Houghton, J. S. Keltie, E. G. Ravenstein.
1887. Manchester	Col. Sir C. Warren, R.E., G.C.M.G., F.R.S., F.R.G.S.	Rev. L. C. Casartelli, J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1888. Bath.........	Col. Sir C. W. Wilson, R.E., K.C.B., F.R.S., F.R.G.S.	J. S. Keltie, H. J. Mackinder, E. G. Ravenstein.
1889. Newcastle-upon-Tyne	Col. Sir F. de Winton, K.C.M.G., C.B., F.R.G.S.	J. S. Keltie, H. J. Mackinder, R. Sulivan, A. Silva White.
1890. Leeds	Lieut.-Col. Sir R. Lambert Playfair, K.C.M.G., F.R.G.S.	A. Barker, John Coles, J. S. Keltie, A. Silva White.
1891. Cardiff......	E. G. Ravenstein, F.R.G.S., F.S.S.	John Coles, J. S. Keltie, H. J. Mackinder, A. Silva White, Dr. Yeats.
1892. Edinburgh	Prof. J. Geikie, D.C.L., F.R.S., V.P.R.Scot.G.S.	J. G. Bartholomew, John Coles, J. S. Keltie, A. Silva White.
1893. Nottingham	H. Seebohm, Sec. R.G.S., F.L.S., F.Z.S.	Col. F. Bailey, John Coles, H. O. Forbes, Dr. H. R. Mill.
1894. Oxford......	Capt. W. J. L. Wharton, R.N., F.R.S.	John Coles, W. S. Dalgleish, H. N. Dickson, Dr. H. R. Mill.
1895. Ipswich ...	H. J. Mackinder, M.A., F.R.G.S.	John Coles, H. N. Dickson, Dr. H. R. Mill, W. A. Taylor.
1896. Liverpool...	Major L. Darwin, Sec. R.G.S.	Col. F. Bailey, H. N. Dickson, Dr. H. R. Mill, E. C. DuB. Phillips.
1897. Toronto ...	J. Scott Keltie, LL.D.	Col. F. Bailey, Capt. Deville, Dr. H. R. Mill, J. B. Tyrrell.
1898. Bristol......	Col. G. Earl Church, F.R.G.S.	H. N. Dickson, Dr. H. R. Mill, H. C. Trapnell.
1899. Dover	Sir John Murray, F.R.S.	H. N. Dickson, Dr. H. O. Forbes, Dr. H. R. Mill.
1900. Bradford ...	Sir George S. Robertson, K.C.S.I.	H. N. Dickson, E. Heawood, E. R. Wethey.
1901. Glasgow ...	Dr. H. R. Mill, F.R.G.S.	H. N. Dickson, E. Heawood, G. Sandeman, A. C. Turner.
1902. Belfast......	Sir T. H. Holdich, K.C.B. ...	G. G. Chisholm, E. Heawood, Dr. A. J. Herbertson, Dr. J. A. Lindsay.

Date and Place	Presidents	Secretaries
1903. Southport	Capt. E. W. Creak, R.N., C.B., F.R.S.	E. Heawood, Dr. A. J. Herbertson, E. A. Reeves, Capt. J. C. Underwood.
1904. Cambridge	Douglas W. Freshfield	E. Heawood, Dr. A. J. Herbertson, H. Y. Oldham, E. A. Reeves.
1905. SouthAfrica	Adm. Sir W. J. L. Wharton, R.N., K.C.B., F.R.S.	A. H. Cornish-Bowden, F. Flowers, Dr. A. J. Herbertson, H. Y. Oldham.
1906. York	Rt. Hon. Sir George Goldie, K.C.M.G., F.R.S.	E. Heawood, Dr. A. J. Herbertson, E. A. Reeves, G. Yeld.
1907. Leicester	George G. Chisholm, M.A.	E. Heawood, O. J. R. Howarth, E. A. Reeves, T. Walker.
1908. Dublin	Major E. H. Hills, C.M.G., R.E.	W. F. Bailey, W. J. Barton, O. J. R. Howarth, E. A. Reeves.
1909. Winnipeg	Col. Sir D. Johnston, K.C.M.G., C.B., R.E.	G. G. Chisholm, J. McFarlane, A. McIntyre.
1910. Sheffield	Prof. A. J. Herbertson, M.A., Ph.D.	Rev. W. J. Barton, Dr. R. Brown, J. McFarlane, E. A. Reeves.
1911. Portsmouth	Col. C. F. Close, R.E., C.M.G.	J. McFarlane, E. A. Reeves, W. P. Smith.

STATISTICAL SCIENCE.

COMMITTEE OF SCIENCES, VI.—STATISTICS.

1833. Cambridge	Prof. Babbage, F.R.S.	J. E. Drinkwater.
1834. Edinburgh	Sir Charles Lemon, Bart.	Dr. Cleland, C. Hope Maclean.

SECTION F.—STATISTICS.

1835. Dublin	Charles Babbage, F.R.S.	W. Greg, Prof. Longfield.
1836. Bristol	Sir Chas. Lemon, Bart., F.R.S.	Rev. J. E. Bromby, C. B. Fripp, James Heywood.
1837. Liverpool	Rt. Hon. Lord Sandon	W. R. Greg, W. Langton, Dr. W. C. Tayler.
1838. Newcastle	Colonel Sykes, F.R.S.	W. Cargill, J. Heywood, W. R. Wood.
1839. Birmingham.	Henry Hallam, F.R.S.	F. Clarke, R. W. Rawson, Dr. W. C. Tayler.
1840. Glasgow	Lord Sandon, M.P., F.R.S.	C. R. Baird, Prof. Ramsay, R. W. Rawson.
1841. Plymouth	Lieut.-Col. Sykes, F.R.S.	Rev. Dr. Byrth, Rev. R. Luney, R. W. Rawson.
1842. Manchester	G. W. Wood, M.P., F.L.S.	Rev. R. Luney, G. W. Ormerod, Dr. W. Cooke Tayler.
1843. Cork	Sir C. Lemon, Bart., M.P.	Dr. D. Bullen, Dr. W. Cooke Tayler.
1844. York	Lieut.-Col. Sykes, F.R.S., F.L.S.	J. Fletcher, J. Heywood, Dr. Laycock.
1845. Cambridge	Rt. Hon. the Earl Fitzwilliam	J. Fletcher, Dr. W. Cooke Tayler.
1846. Southampton.	G. R. Porter, F.R.S.	J. Fletcher, F. G. P. Neison, Dr. W. C. Tayler, Rev. T. L. Shapcott.
1847. Oxford	Travers Twiss, D.C.L., F.R.S.	Rev. W. H. Cox, J. J. Danson, F. G. P. Neison.
1848. Swansea	J. H. Vivian, M.P., F.R.S.	J. Fletcher, Capt. R. Shortrede.
1849. Birmingham.	Rt. Hon. Lord Lyttelton	Dr. Finch, Prof. Hancock, F. G. P. Neison.
1850. Edinburgh	Very Rev. Dr. John Lee, V.P.R.S.E.	Prof. Hancock, J. Fletcher, Dr. J. Stark.
1851. Ipswich	Sir John P. Boileau, Bart.	J. Fletcher, Prof. Hancock.
1852. Belfast	His Grace the Archbishop of Dublin.	Prof. Hancock, Prof. Ingram, James MacAdam, jun.

Date and Place	Presidents	Secretaries
1853. Hull	James Heywood, M.P., F.R.S.	Edward Cheshire, W. Newmarch.
1854. Liverpool...	Thomas Tooke, F.R.S.	E. Cheshire, J. T. Danson, Dr. W. H. Duncan, W. Newmarch.
1855. Glasgow ...	R. Monckton Milnes, M.P. ...	J. A. Campbell, E. Cheshire, W. Newmarch, Prof. R. H. Wash.

SECTION F (*continued*).—ECONOMIC SCIENCE AND STATISTICS.

1856. Cheltenham	Rt. Hon. Lord Stanley, M.P.	Rev. C. H. Bromby, E. Cheshire, Dr. W. N. Hancock, W. Newmarch, W. M. Tartt.
1857. Dublin	His Grace the Archbishop of Dublin, M.R.I.A.	Prof. Cairns, Dr. H. D. Hutton, W. Newmarch.
1858. Leeds	Edward Baines	T. B. Baines, Prof. Cairns, S. Brown, Capt. Fishbourne, Dr. J. Strang.
1859. Aberdeen...	Col. Sykes, M.P., F.R.S.	Prof. Cairns, Edmund Macrory, A. M. Smith, Dr. John Strang.
1860. Oxford	Nassau W. Senior, M.A.	Edmund Macrory, W. Newmarch, Prof. J. E. T. Rogers.
1861. Manchester	William Newmarch, F.R.S....	David Chadwick, Prof. R. C. Christie, E. Macrory, Prof. J. E. T. Rogers.
1862. Cambridge	Edwin Chadwick, C.B.	H. D. Macleod, Edmund Macrory.
1863. Newcastle	William Tite, M.P., F.R.S. ...	T. Doubleday, Edmund Macrory, Frederick Purdy, James Potts.
1864. Bath	W. Farr, M.D., D.C.L., F.R.S.	E. Macrory, E. T. Payne, F. Purdy.
1865. Birmingham.	Rt. Hon. Lord Stanley, LL.D., M.P.	G. J. D. Goodman, G. J. Johnston, E. Macrory.
1866. Nottingham	Prof. J. E. T. Rogers	R. Birkin, jun., Prof. Leone Levi, E. Macrory.
1867. Dundee	M. E. Grant-Duff, M.P.	Prof. Leone Levi, E. Macrory, A. J. Warden.
1868. Norwich	Samuel Brown	Rev. W. C. Davie, Prof. Leone Levi.
1869. Exeter	Rt. Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	E. Macrory, F. Purdy, C. T. D. Acland.
1870. Liverpool...	Prof. W. Stanley Jevons, M.A.	Chas. R. Dudley Baxter, E. Macrory, J. Miles Moss.
1871. Edinburgh	Rt. Hon. Lord Neaves	J. G. Fitch, James Meikle.
1872 Brighton ...	Prof. Henry Fawcett, M.P. ...	J. G. Fitch, Barclay Phillips.
1873. Bradford ...	Rt. Hon. W. E. Forster, M.P.	J. G. Fitch, Swire Smith.
1874. Belfast	Lord O'Hagan	Prof. Donnell, F. P. Fellows, Hans MacMordie.
1875. Bristol	James Heywood, M.A., F.R.S., Pres. S.S.	F. P. Fellows, T. G. P. Hallett, E. Macrory.
1876. Glasgow ...	Sir George Campbell, K.C.S.I., M.P.	A. M'Neel Caird, T. G. P. Hallett, Dr. W. Neilson Hancock, Dr. W. Jack.
1877. Plymouth...	Rt. Hon. the Earl Fortescue	W. F. Collier, P. Hallett, J. T. Pim.
1878. Dublin	Prof. J. K. Ingram, LL.D. ...	W. J. Hancock, C. Molloy, J. T. Pim.
1879. Sheffield ...	G. Shaw Lefevre, M.P., Pres. S.S.	Prof. Adamson, R. E. Leader, C. Molloy.
1880. Swansea ...	G. W. Hastings, M.P.	N. A. Humphreys, C. Molloy.
1881. York	Rt. Hon. M. E. Grant-Duff, M.A., F.R.S.	C. Molloy, W. W. Morrell, J. F. Moss.
1882. Southampton.	Rt. Hon. G. Sclater-Booth, M.P., F.R.S.	G. Baden-Powell, Prof. H. S. Foxwell, A. Milnes, C. Molloy.
1883. Southport	R. H. Inglis Palgrave, F.R.S.	Rev. W. Cunningham, Prof. H. S. Foxwell, J. N. Keynes, C. Molloy.
1884. Montreal ...	Sir Richard Temple, Bart., G.C.S.I., C.I.E., F.R.G.S.	Prof. H. S. Foxwell, J. S. McLennan, Prof. J. Watson.
1885. Aberdeen...	Prof. H. Sidgwick, LL.D., Litt.D.	Rev. W. Cunningham, Prof. H. S. Foxwell, C. McCombie, J. F. Moss.

Date and Place	Presidents	Secretaries
1886. Birmingham.	J. B. Martin, M.A., F.S.S. ...	F. F. Barham, Rev. W. Cunningham, Prof. H. S. Foxwell, J. F. Moss.
1887. Manchester	Robert Giffen, LL.D.,V.P.S.S.	Rev. W. Cunningham, F. Y. Edgeworth, T. H. Elliott, C. Hughes, J. E. C. Munro, G. H. Sargant.
1888. Bath.........	Rt. Hon. Lord Bramwell, LL.D., F.R.S.	Prof. F. Y. Edgeworth, T. H. Elliott, H. S. Foxwell, L. L. F. R. Price.
1889. Newcastle-upon-Tyne	Prof. F. Y. Edgeworth, M.A., F.S.S.	Rev. Dr. Cunningham, T. H. Elliott, F. B. Jevons, L. L. F. R. Price.
1890. Leeds	Prof. A. Marshall, M.A., F.S.S.	W. A. Brigg, Rev. Dr. Cunningham, T. H. Elliott, Prof. J. E. C. Munro, L. L. F. R. Price.
1891. Cardiff.. ...	Prof. W. Cunningham, D.D., D.Sc., F S.S.	Prof. J. Brough, E. Cannan, Prof. E. C. K. Gonner, H. Ll. Smith, Prof. W. R. Sorley.
1892. Edinburgh	Hon. Sir C. W. Fremantle, K.C.B.	Prof. J. Brough, J. R. Findlay, Prof. E. C. K. Gonner, H. Higgs, L. L. F. R. Price.
1893. Nottingham	Prof. J. S. Nicholson, D.Sc., F.S.S.	Prof. E. C. K. Gonner, H. de B. Gibbins, J. A. H. Green, H. Higgs, L. L. F. R. Price.
1894. Oxford......	Prof. C. F. Bastable, M.A., F.S.S.	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1895. Ipswich ...	L. L. Price, M.A.	E. Cannan, Prof. E. C. K. Gonner, H. Higgs.
1896. Liverpool...	Rt. Hon. L. Courtney, M.P....	E. Cannan, Prof. E. C. K. Gonner, W. A. S. Hewins, H. Higgs.
1897. Toronto ...	Prof. E. C. K. Gonner, M.A.	E. Cannan, H. Higgs, Prof. A. Shortt.
1898. Bristol	J. Bonar, M.A., LL.D..........	E. Cannan, Prof. A. W. Flux, H. Higgs, W. E. Tanner.
1899. Dover	H. Higgs, LL.B.	A. L. Bowley, E. Cannan, Prof. A. W. Flux, Rev. G. Sarson.
1900. Bradford ...	Major P. G. Craigie, V.P.S.S.	A. L. Bowley, E. Cannan, S. J. Chapman, F. Hooper.
1901. Glasgow ...	Sir R. Giffen, K.C.B., F.R.S.	W. W. Blackie, A. L. Bowley, E. Cannan, S. J. Chapman.
1902. Belfast ...	E. Cannan, M.A., LL.D.	A. L. Bowley, Prof. S. J. Chapman, Dr. A. Duffin.
1903. Southport	E. W. Brabrook, C.B.	A. L. Bowley, Prof. S. J. Chapman, Dr. B. W. Ginsburg, G. Lloyd.
1904. Cambridge	Prof. Wm. Smart, LL.D.	J. E. Bidwell, A. L. Bowley, Prof. S. J. Chapman, Dr. B. W. Ginsburg.
1905. SouthAfrica	Rev. W. Cunningham, D.D., D.Sc.	R. à Ababrelton, A. L. Bowley, Prof. H. E. S. Fremantle, H. O. Meredith.
1906. York.........	A. L. Bowley, M.A.	Prof. S. J. Chapman, D. H. Macgregor, H. O. Meredith, B. S. Rowntree.
1907. Leicester ...	Prof. W. J. Ashley, M.A.......	Prof. S. J. Chapman, D. H. Macgregor, H. O. Meredith, T. S. Taylor.
1908. Dublin......	W. M. Acworth, M.A.	W. G. S. Adams, Prof. S. J. Chapman, Prof. D. H. Macgregor, H. O. Meredith.
	Sub-section of Agriculture—Rt. Hon. Sir H. Plunkett.	A. D. Hall, Prof. J. Percival, J. H. Priestley, Prof. J. Wilson.
1909. Winnipeg...	Prof. S. J. Chapman, M.A. ...	Prof. A. B. Clark, Dr. W. A. Manahan, Dr. W. R. Scott.
1910. Sheffield ...	Sir H. Llewellyn Smith, K.C.B., M.A.	C. R. Fay, H. O. Meredith, Dr. W. R. Scott, R. Wilson.
1911. Portsmouth	Hon. W. Pember Reeves......	C. R. Fay, Dr. W. R. Scott, H. A. Stibbs.

SECTION G.—MECHANICAL SCIENCE.

Date and Place	Presidents	Secretaries
1836. Bristol	Davies Gilbert, D.C.L., F.R.S.	T. G. Bunt, G. T. Clark, W. West.
1837. Liverpool...	Rev. Dr. Robinson	Charles Vignoles, Thomas Webster.
1838. Newcastle	Charles Babbage, F.R.S.	R. Hawthorn, C. Vignoles, T. Webster.
1839. Birmingham.	Prof. Willis, F.R.S., and Robt. Stephenson.	W. Carpmael, William Hawkes, T. Webster.
1840. Glasgow	Sir John Robinson	J. Scott Russell, J. Thomson, J. Tod, C. Vignoles.
1841. Plymouth...	John Taylor, F.R.S.	Henry Chatfield, Thomas Webster.
1842. Manchester	Rev. Prof. Willis, F.R.S.	J. F. Bateman, J. Scott Russell, J. Thomson, Charles Vignoles.
1843. Cork	Prof. J. Macneill, M.R.I.A....	James Thomson, Robert Mallet.
1844. York	John Taylor, F.R.S.	Charles Vignoles, Thomas Webster.
1845. Cambridge	George Rennie, F.R.S.........	Rev. W. T. Kingsley.
1846. Southampton.	Rev. Prof. Willis, M.A., F.R.S.	William Betts, jun., Charles Manby.
1847. Oxford	Rev. Prof. Walker, M.A., F.R.S.	J. Glynn, R. A. Le Mesurier.
1848. Swansea ...	Rev. Prof. Walker, M.A., F.R.S.	R. A. Le Mesurier, W. P. Struvé.
1849. Birmingham	Robt. Stephenson, M.P., F.R.S.	Charles Manby, W. P. Marshall.
1850. Edinburgh	Rev. R. Robinson	Dr. Lees, David Stephenson.
1851. Ipswich ...	William Cubitt, F.R.S.........	John Head, Charles Manby.
1852. Belfast......	John Walker, C.E., LL.D., F.R.S.	John F. Bateman, C. B. Hancock, Charles Manby, James Thomson.
1853. Hull	William Fairbairn, F.R.S. ...	J. Oldham, J. Thomson, W. S. Ward.
1854. Liverpool...	John Scott Russell, F.R.S. ...	J. Grantham, J. Oldham, J. Thomson.
1855. Glasgow ...	W. J. M. Rankine, F.R.S. ...	L. Hill, W. Ramsay, J. Thomson.
1856. Cheltenham	George Rennie, F.R.S.	C. Atherton, B. Jones, H. M. Jeffery.
1857. Dublin......	Rt. Hon. the Earl of Rosse, F.R.S.	Prof. Downing, W.T. Doyne, A. Tate, James Thomson, Henry Wright.
1858. Leeds	William Fairbairn, F.R.S. ...	J. C. Dennis, J. Dixon, H. Wright.
1859. Aberdeen...	Rev. Prof. Willis, M.A., F.R.S.	R. Abernethy, P. Le Neve Foster, H. Wright.
1860. Oxford	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, Rev. F. Harrison, Henry Wright.
1861. Manchester	J. F. Bateman, C.E., F.R.S....	P. Le Neve Foster, John Robinson, H. Wright.
1862. Cambridge	William Fairbairn, F.R.S. ...	W. M. Fawcett, P. Le Neve Foster.
1863. Newcastle	Rev. Prof. Willis, M.A., F.R.S.	P. Le Neve Foster, P. Westmacott, J. F. Spencer
1864. Bath.........	J. Hawkshaw, F.R.S.	P. Le Neve Foster, Robert Pitt.
1865. Birmingham.	Sir W. G. Armstrong, LL.D., F.R.S.	P. Le Neve Foster, Henry Lea, W. P. Marshall, Walter May.
1866. Nottingham	Thomas Hawksley, V.P. Inst. C.E., F.G.S.	P. Le Neve Foster, J. F. Iselin, M. O. Tarbotton.
1867. Dundee......	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	P. Le Neve Foster, John P. Smith, W. W. Urquhart.
1868. Norwich ...	G. P. Bidder, C.E., F.R.G.S.	P. Le Neve Foster, J. F. Iselin, C. Manby, W. Smith.
1869. Exeter	C. W. Siemens, F.R.S..........	P. Le Neve Foster, H. Bauerman.
1870. Liverpool...	Chas. B. Vignoles, C.E., F.R.S.	H. Bauerman, P. Le Neve Foster, T. King, J. N. Shoolbred.
1871. Edinburgh	Prof. Fleeming Jenkin, F.R.S.	H. Bauerman, A. Leslie, J. P. Smith.
1872. Brighton ...	F. J. Bramwell, C.E.	H. M. Brunel, P. Le Neve Foster, J. G. Gamble, J. N. Shoolbred.
1873. Bradford ...	W. H. Barlow, F.R.S.	C. Barlow, H. Bauerman, E. H. Carbutt, J. C. Hawkshaw, J. N. Shoolbred

Date and Place	Presidents	Secretaries
1874. Belfast	Prof. James Thomson, LL.D., C.E., F.R.S.E.	A. T. Atchison, J. N. Shoolbred, John Smyth, jun.
1875. Bristol	W. Froude, C.E., M.A., F.R.S.	W. R. Browne, H. M. Brunel, J. G. Gamble, J. N. Shoolbred.
1876. Glasgow	C. W. Merrifield, F.R.S.	W. Bottomley, jun., W. J. Millar, J. N. Shoolbred, J. P. Smith.
1877. Plymouth	Edward Woods, C.E.	A. T. Atchison, Dr. Merrifield, J. N. Shoolbred.
1878. Dublin	Edward Easton, C.E.	A. T. Atchison, R. G. Symes, H. T. Wood.
1879. Sheffield	J. Robinson, Pres. Inst. Mech. Eng.	A. T. Atchison, Emerson Bainbridge, H. T. Wood.
1880. Swansea	J. Abernethy, F.R.S.E.	A. T. Atchison, H. T. Wood.
1881. York	Sir W. G. Armstrong, C.B., LL.D., D.C.L., F.R.S.	A. T. Atchison, J. F. Stephenson, H. T. Wood.
1882. Southampton.	John Fowler, C.E., F.G.S.	A. T. Atchison, F. Churton, H. T. Wood.
1883. Southport	J. Brunlees, Pres.Inst.C.E.	A. T. Atchison, E. Rigg, H. T. Wood.
1884. Montreal	Sir F. J. Bramwell, F.R.S., V.P.Inst.C.E.	A. T. Atchison, W. B. Dawson, J. Kennedy, H. T. Wood.
1885. Aberdeen	B. Baker, M.Inst.C.E.	A. T. Atchison, F. G. Ogilvie, E. Rigg, J. N. Shoolbred.
1886. Birmingham.	Sir J. N. Douglass, M.Inst. C.E.	C. W. Cooke, J. Kenward, W. B. Marshall, E. Rigg.
1887. Manchester	Prof. Osborne Reynolds, M.A., LL.D., F.R.S.	C. F. Budenberg, W. B. Marshall, E. Rigg.
1888. Bath	W. H. Preece, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, E. Rigg, P. K. Stothert.
1889. Newcastle-upon-Tyne.	W. Anderson, M.Inst.C.E.	C. W. Cooke, W. B. Marshall, Hon. C. A. Parsons, E. Rigg.
1890. Leeds	Capt. A. Noble, C.B., F.R.S., F.R.A.S.	E. K. Clark, C. W. Cooke, W. B. Marshall, E. Rigg.
1891. Cardiff	T. Forster Brown, M.Inst.C.E.	C. W. Cooke, Prof. A. C. Elliott, W. B. Marshall, E. Rigg.
1892. Edinburgh	Prof. W. C. Unwin, F.R.S., M.Inst.C.E.	C. W. Cooke, W. B. Marshall, W. C. Popplewell, E. Rigg.
1893. Nottingham	Jeremiah Head, M.Inst.C.E., F.C.S.	C. W. Cooke, W. B. Marshall, E. Rigg, H. Talbot.
1894. Oxford	Prof. A. B. W. Kennedy, F.R.S., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, Rev. F. J. Smith.
1895. Ipswich	Prof. L. F. Vernon-Harcourt, M.A., M.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, W. B. Marshall, P. G. M. Stoney.
1896. Liverpool	Sir Douglas Fox, V.P.Inst.C.E.	Prof. T. Hudson Beare, C. W. Cooke, S. Dunkerley, W. B. Marshall.
1897. Toronto	G. F. Deacon, M.Inst.C.E.	Prof. T. Hudson Beare, Prof. Callendar, W. A. Price.
1898. Bristol	Sir J. Wolfe-Barry, K.C.B., F.R.S.	Prof. T. H. Beare, Prof. J. Munro, H. W. Pearson, W. A. Price.
1899. Dover	Sir W. White, K.C.B., F.R.S.	Prof. T. H. Beare, W. A. Price, H. E. Stilgoe.
1900. Bradford[1]	Sir Alex. R. Binnie, M.Inst. C.E.	Prof. T. H. Beare, C. F. Charnock, Prof. S. Dunkerley, W. A. Price.

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[1] The title of Section G was changed to Engineering.

SECTION G.—ENGINEERING.

Date and Place	Presidents	Secretaries
1901. Glasgow ...	R. E. Crompton, M.Inst.C.E.	H. Bamford, W. E. Dalby, W. A. Price.
1902. Belfast ...	Prof. J. Perry, F.R.S.	M. Barr, W. A. Price, J. Wylie.
1903. Southport	C. Hawksley, M.Inst.C.E. ...	Prof. W. E. Dalby, W. T. Maccall, W. A. Price.
1904. Cambridge	Hon. C. A. Parsons, F.R.S....	J. B. Peace, W. T. Maccall, W. A. Price.
1905. South Africa	Col. Sir C. Scott-Moncrieff, G.C.S.I., K.C.M.G., R.E.	W. T. Maccall, W. B. Marshall, Prof. H. Payne, E. Williams.
1906. York.........	J. A. Ewing, F.R.S.	W. T. Maccall, W. A. Price, J. Triffit.
1907. Leicester ...	Prof. Silvanus P. Thompson, F.R.S.	Prof. E. G. Coker, A. C. Harris, W. A. Price, H. E. Wimperis.
1908. Dublin	Dugald Clerk, F.R.S.	Prof. E. G. Coker, Dr. W. E. Lilly, W. A. Price, H. E. Wimperis.
1909. Winnipeg...	Sir W. H. White, K.C.B., F.R.S.	E. E. Brydone-Jack, Prof. E. G. Coker, Prof. E. W. Marchant, W. A. Price.
1910. Sheffield ..	Prof. W. E. Dalby, M.A., M.Inst.C.E.	F. Boulden, Prof. E. G. Coker, A. A. Rowse, H. E. Wimperis.
1911. Portsmouth	Prof. J. H. Biles, LL.D., D.Sc.	H. Ashley, Prof. E. G. Coker, A. A. Rowse, H. E. Wimperis.

SECTION H.—ANTHROPOLOGY.

Date and Place	Presidents	Secretaries
1884. Montreal...	E. B. Tylor, D.C.L., F.R.S. ...	G. W. Bloxam, W. Hurst.
1885. Aberdeen...	Francis Galton, M.A., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. A. Macgregor.
1886. Birmingham.	Sir G. Campbell, K.C.S.I., M.P., D.C.L., F.R.G.S.	G. W. Bloxam, Dr. J. G. Garson, W. Hurst, Dr. R. Saundby.
1887. Manchester	Prof. A. H. Sayce, M.A.	G. W. Bloxam, Dr. J. G. Garson, Dr. A. M. Paterson
1888. Bath.........	Lieut.-General Pitt-Rivers, D.C.L., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, J. Harris Stone.
1889. Newcastle-upon-Tyne	Prof. Sir W. Turner, M.B., LL.D., F.R.S.	G. W. Bloxam, Dr. J. G. Garson, Dr. R. Morison, Dr. R. Howden.
1890. Leeds	Dr. J. Evans, Treas. R.S., F.S.A., F.L.S., F.G.S.	G. W. Bloxam, Dr. C. M. Chadwick, Dr. J. G. Garson.
1891. Cardiff......	Prof. F. Max Müller, M.A. ...	G. W. Bloxam, Prof. R. Howden, H. Ling Roth, E. Seward.
1892. Edinburgh	Prof. A. Macalister, M.A., M.D., F.R.S.	G. W. Bloxam, Dr. D. Hepburn, Prof. R. Howden, H. Ling Roth.
1893. Nottingham	Dr. R. Munro, M.A., F.R.S.E.	G. W. Bloxam, Rev. T. W. Davies, Prof. R. Howden, F. B. Jevons, J. L. Myres.
1894. Oxford......	Sir W. H. Flower, K.C.B., F.R.S.	H. Balfour, Dr. J. G. Garson, H. Ling Roth.
1895. Ipswich ...	Prof. W. M. Flinders Petrie, D.C.L.	J. L. Myres, Rev. J. J. Raven, H. Ling Roth.
1896. Liverpool...	Arthur J. Evans, F.S.A.	Prof. A. C. Haddon, J. L. Myres, Prof. A. M. Paterson.
1897. Toronto ...	Sir W. Turner, F.R.S.	A. F. Chamberlain, H. O. Forbes, Prof. A. C. Haddon, J. L. Myres.
1898. Bristol......	E. W. Brabrook, C.B.	H. Balfour, J. L. Myres, G. Parker.
1899. Dover	C. H. Read, F.S.A.	H. Balfour, W. H. East, Prof. A. C. Haddon, J. L. Myres.
1900. Bradford...	Prof. John Rhys, M.A..........	Rev. E. Armitage, H. Balfour, W. Crooke, J. L. Myres.
1901. Glasgow ...	Prof. D. J. Cunningham, F.R.S.	W. Crooke, Prof. A. F. Dixon, J. F. Gemmill, J. L. Myres.
1902. Belfast ...	Dr. A. C. Haddon, F.R.S. ...	R. Campbell, Prof. A. F. Dixon, J. L. Myres.

Date and Place	Presidents	Secretaries
1903. Southport...	Prof. J. Symington, F.R.S. ...	E. N. Fallaize, H. S. Kingsford, E. M. Littler, J. L. Myres.
1904. Cambridge	H. Balfour, M.A.	W. L. H. Duckworth, E. N. Fallaize, H. S. Kingsford, J. L. Myres.
1905. SouthAfrica	Dr. A. C. Haddon, F.R.S. ...	A. R. Brown, A. von Dessauer, E. S. Hartland.
1906. York.........	E. Sidney Hartland, F.S.A....	Dr. G. A. Auden, E. N. Fallaize, H. S. Kingsford, Dr. F. C. Shrubsall.
1907. Leicester ..	D. G. Hogarth, M.A............	C. J. Billson, E. N. Fallaize, H. S. Kingsford, Dr. F. C. Shrubsall.
1908. Dublin	Prof. W. Ridgeway, M.A. ...	E. N. Fallaize, H. S. Kingsford, Dr. F. C. Shrubsall, L. E. Steele.
1909. Winnipeg...	Prof. J. L. Myres, M.A.	H. S. Kingsford, Prof. C. J. Patten, Dr. F. C. Shrubsall.
1910. Sheffield ...	W. Crooke, B.A.	E. N Fallaize, H. S. Kingsford, Prof. C. J. Patten, Dr. F. C. Shrubsall
1911. Portsmouth	W. H. R. Rivers, M.D., F.R.S.	E. N. Fallaize, H. S. Kingsford, E. W. Martindell, H. Rundle, Dr. F. C. Shrubsall.

SECTION I.—PHYSIOLOGY (including EXPERIMENTAL PATHOLOGY AND EXPERIMENTAL PSYCHOLOGY).

1894. Oxford......	Prof. E. A. Schäfer, F.R.S., M.R.C.S.	Prof. F. Gotch, Dr. J. S. Haldane, M. S. Pembrey.
1896. Liverpool ..	Dr. W. H. Gaskell, F.R.S. ...	Prof. R. Boyce, Prof. C. S. Sherrington.
1897. Toronto ...	Prof. Michael Foster, F.R.S.	Prof. R. Boyce, Prof. C. S. Sherrington, Dr. L. E. Shore.
1899. Dover	J. N. Langley, F.R.S.	Dr. Howden, Dr. L. E. Shore, Dr. E. H. Starling.
1901. Glasgow ...	Prof. J. G. McKendrick, F.R.S.	W. B. Brodie, W. A. Osborne, Prof. W. H. Thompson.
1902. Belfast ...	Prof. W. D. Halliburton, F.R.S.	J. Barcroft, Dr. W. A. Osborne, Dr. C. Shaw.
1904. Cambridge	Prof. C. S. Sherrington, F.R.S.	J. Barcroft, Prof. T. G. Brodie, Dr. L. E. Shore.
1905. SouthAfrica	Col. D. Bruce, C.B., F.R.S. ...	J. Barcroft, Dr. Baumann, Dr. Mackenzie, Dr. G. W. Robertson, Dr. Stanwell.
1906. York.........	Prof. F. Gotch, F.R.S..........	J. Barcroft, Dr. J. M. Hamill, Prof. J. S. Macdonald, Dr. D. S. Long.
1907. Leicester...	Dr. A. D. Waller, F.R.S.	Dr. N. H. Alcock, J. Barcroft, Prof. J. S. Macdonald, Dr. A. Warner.
1908. Dublin......	Dr. J. Scott Haldane, F.R.S.	Prof. D J. Coffey, Dr. P. T. Herring, Prof. J. S. Macdonald, Dr. H. E. Roaf.
1909. Winnipeg...	Prof. E. H. Starling, F.R.S....	Dr. N. H. Alcock, Prof. P. T. Herring, Dr. W. Webster.
1910. Sheffield ...	Prof. A. B. Macallum, F.R.S.	Dr. H. G. M. Henry, Keith Lucas, Dr. H. E. Roaf, Dr. J. Tait.
1911. Portsmouth	Prof. J. S. Macdonald, B.A.	Dr. J. T. Leon, Dr. Keith Lucas, Dr. H. E. Roaf, Dr. J. Tait.

SECTION K.—BOTANY.

1895. Ipswich ...	W. T. Thiselton-Dyer, F.R.S	A. C. Seward, Prof. F. E. Weiss.
1896. Liverpool...	Dr. D. H. Scott, F.R.S.	Prof. Harvey Gibson, A. C. Seward, Prof. F. E. Weiss.
1897. Toronto ...	Prof. Marshall Ward, F.R.S.	Prof. J. B. Farmer, E. C. Jeffrey, A. C. Seward, Prof. F. E. Weiss.

Date and Place	Presidents	Secretaries
1898. Bristol	Prof. F. O. Bower, F.R.S. ...	A. C. Seward, H. Wager, J. W. White.
1899. Dover	Sir George King, F.R.S.	G. Dowker, A. C. Seward, H. Wager.
1900. Bradford ...	Prof. S. H. Vines, F.R.S.	A. C. Seward, H. Wager, W. West.
1901. Glasgow ...	Prof. I. B. Balfour, F.R.S. ...	D. T. Gwynne-Vaughan, G. F. Scott-Elliot, A. C. Seward, H. Wager.
1902. Belfast ...	Prof. J. R. Green, F.R.S.	A. G. Tansley, Rev. C. H. Waddell, H. Wager, R. H. Yapp.
1903. Southport	A. C. Seward, F.R.S.	H. Ball, A. G. Tansley, H. Wager, R. H. Yapp.
1904. Cambridge	Francis Darwin, F.R.S. ...... *Sub-section of Agriculture*—Dr. W. Somerville.	Dr. F. F. Blackman, A. G. Tansley, H. Wager, T. B. Wood, R. H. Yapp.
1905. South Africa	Harold Wager, F.R.S.	R. P. Gregory, Dr. Marloth, Prof. Pearson, Prof. R. H. Yapp.
1906. York.........	Prof. F. W. Oliver, F.R.S. ...	Dr. A. Burtt, R. P. Gregory, Prof. A. G. Tansley, Prof. R. H. Yapp.
1907. Leicester ...	Prof. J. B. Farmer, F.R.S. ...	W. Bell, R. P. Gregory, Prof. A. G. Tansley, Prof. R. H. Yapp.
1908. Dublin	Dr. F. F. Blackman, F.R.S....	Prof. H. H. Dixon, R. P. Gregory, A. G. Tansley, Prof. R. H. Yapp.
1909. Winnipeg...	Lieut.-Col. D. Prain, C.I.E., F.R.S.	Prof. A. H. R. Buller, Prof. D. T. Gwynne-Vaughan, Prof. R. H. Yapp.
	Sub-section of Agriculture—Major P. G. Craigie, C.B.	W. J. Black, Dr. E. J. Russell, Prof. J. Wilson.
1910. Sheffield ...	Prof. J. W. H. Trail, F.R.S.	B. H. Bentley, R. P. Gregory, Prof. D. T. Gwynne-Vaughan, Prof. R. H. Yapp.
1911. Portsmouth	Prof. F. E. Weiss, D.Sc.	C. G. Delahunt, Prof. D. T. Gwynne-Vaughan, Dr. C. E. Moss, Prof. R. H. Yapp.
	Sub-section of Agriculture[1] W. Bateson, M.A., F.R.S.	J. Golding, H. R. Pink, Dr. E. J. Russell.

SECTION L.—EDUCATIONAL SCIENCE.

1901. Glasgow ...	Sir John E. Gorst, F.R.S. ...	R. A. Gregory, W. M. Heller, R. Y. Howie, C. W. Kimmins, Prof. H. L. Withers.
1902. Belfast ...	Prof. H. E. Armstrong, F.R.S.	Prof. R. A. Gregory, W. M. Heller, R. M. Jones, Dr. C. W. Kimmins, Prof. H. L. Withers.
1903. Southport ..	Sir W. de W. Abney, K.C.B., F.R.S.	Prof. R. A. Gregory, W. M. Heller, Dr. C. W. Kimmins, Dr. H. L. Snape.
1904. Cambridge	Bishop of Hereford, D.D. ...	J. H. Flather, Prof. R. A. Gregory, W. M. Heller, Dr. C. W. Kimmins.
1905. South Africa	Prof. Sir R. C. Jebb, D.C.L., M.P.	A. D. Hall, Prof. Hele-Shaw, Dr. C. W. Kimmins, J. R. Whitton.
1906. York.........	Prof. M. E. Sadler, LL.D. ...	Prof. R. A. Gregory, W. M. Heller, Hugh Richardson.
1907. Leicester ...	Sir Philip Magnus, M.P.	W. D. Eggar, Prof. R. A. Gregory, J. S. Laver, Hugh Richardson.
1908. Dublin	Prof. L. C. Miall, F.R.S.	Prof. E. P. Culverwell, W. D. Eggar, George Fletcher, Prof. R. A. Gregory, Hugh Richardson.
1909. Winnipeg...	Rev. H. B. Gray, D.D.	W. D. Eggar, R. Fletcher, J. L. Holland, Hugh Richardson.
1910. Sheffield ...	Principal H. A. Miers, F.R.S.	A. J. Arnold, W. D. Eggar, J. L. Holland, Hugh Richardson.
1911. Portsmouth	Rt. Rev. J. E. C. Welldon, D.D.	W. D. Eggar, O. Freeman, J. L. Holland, Hugh Richardson.

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[1] A Section of Agriculture, M, was constituted at the close of this Meeting.

CHAIRMEN AND SECRETARIES OF THE CONFERENCES OF DELEGATES OF CORRESPONDING SOCIETIES.

Date and Place	Chairmen	Secretaries
1885. Aberdeen...	Francis Galton, F.R.S..........	Prof. Meldola.
1886. Birmingham	Prof. A. W. Williamson, F.R.S.	Prof. Meldola, F.R.S.
1887. Manchester	Prof. W. Boyd Dawkins, F.R.S.	Prof. Meldola, F.R.S.
1888. Bath.........	John Evans, F.R.S.	Prof. Meldola, F.R.S.
1889. Newcastle-upon-Tyne	Francis Galton, F.R.S..........	Prof. G. A. Lebour.
1890. Leeds	G. J. Symons, F.R.S.	Prof. Meldola, F.R.S.
1891. Cardiff......	G. J. Symons, F.R.S.	Prof. Meldola, F.R.S.
1892. Edinburgh	Prof. Meldola, F.R.S.	T. V. Holmes.
1893. Nottingham	Dr. J. G. Garson	T. V. Holmes.
1894. Oxford......	Prof. Meldola, F.R.S.	T. V. Holmes.
1895. Ipswich ...	G. J. Symons, F.R.S.	T. V. Holmes.
1896. Liverpool..	Dr J. G. Garson	T. V. Holmes.
1897. Toronto ...	Prof. Meldola, F.R.S.	J. Hopkinson.
1898. Bristol......	W. Whitaker, F.R.S.	T. V. Holmes.
1899. Dover	Rev. T. R. R. Stebbing, F.R.S.	T. V. Holmes.
1900. Bradford ...	Prof. E. B. Poulton, F.R.S. ...	T. V. Holmes.
1901. Glasgow ...	F. W. Rudler, F.G.S.	Dr. J. G. Garson, A. Somerville
1902 Belfast......	Prof. W. W. Watts, F.G.S. ...	E. J. Bles.
1903. Southport..	W. Whitaker, F.R.S.	F. W Rudler.
1904. Cambridge	Prof. E. H. Griffiths, F.R.S	F W. Rudler.
1905. London ...	Dr. A. Smith Woodward, F.R.S.	F. W. Rudler.
1906. York.........	Sir Edward Brabrook, C.B....	F. W. Rudler.
1907. Leicester...	H. J. Mackinder, M.A..........	F. W. Rudler, I.S.O.
1908. Dublin......	Prof. H. A. Miers, F.R.S......	W. P. D. Stebbing.
1909. London ...	Dr. A. C. Haddon, F.R.S. ...	W. P. D. Stebbing.
1910. Sheffield ...	Dr. Tempest Anderson.........	W. P. D. Stebbing.
1911. Portsmouth	Prof J. W. Gregory, F.R.S....	W. P. D. Stebbing.

EVENING DISCOURSES.

Date and Place	Lecturers	Subject of Discourse
1842. Manchester	Charles Vignoles, F.R.S......	The Principles and Construction of Atmospheric Railways.
	Sir M. I. Brunel	The Thames Tunnel.
	R. I. Murchison..................	The Geology of Russia.
1843. Cork	Prof. Owen, M.D., F.R.S.......	The Dinornis of New Zealand.
	Prof. E. Forbes, F.R.S..........	The Distribution of Animal Life in the Ægean Sea.
	Dr. Robinson	The Earl of Rosse's Telescope.
1844. York	Charles Lyell, F.R.S.	Geology of North America.
	Dr. Falconer, F.R.S.............	The Gigantic Tortoise of the Siwalik Hills in India.
1845. Cambridge	G. B. Airy, F.R.S., Astron. Royal	Progress of Terrestrial Magnetism.
	R. I. Murchison, F.R.S.	Geology of Russia.
1846. Southampton.	Prof. Owen, M.D., F.R.S.	Fossil Mammalia of the British Isles.
	Charles Lyell, F.R.S.	Valley and Delta of the Mississippi.
	W. R. Grove, F.R.S............	Properties of the Explosive Substance discovered by Dr. Schönbein; also some Researches of his own on the Decomposition of Water by Heat.

Date and Place	Lecturers	Subject of Discourse
1847. Oxford......	Rev. Prof. B. Powell, F.R.S.	Shooting Stars.
	Prof. M. Faraday, F.R.S.......	Magnetic and Diamagnetic Phenomena.
	Hugh E. Strickland, F.G.S....	The Dodo (*Didus ineptus*).
1848. Swansea ...	John Percy, M.D., F.R.S.......	Metallurgical Operations of Swansea and its Neighbourhood.
	W. Carpenter, M.D., F.R.S....	Recent Microscopical Discoveries.
1849. Birmingham.	Dr. Faraday, F.R.S.	Mr. Gassiot's Battery.
	Rev. Prof. Willis, M.A., F.R.S.	Transit of different Weights with varying Velocities on Railways.
1850. Edinburgh	Prof. J. H. Bennett, M.D., F.R.S.E.	Passage of the Blood through the minute vessels of Animals in connection with Nutrition.
	Dr. Mantell, F.R.S.	Extinct Birds of New Zealand.
1851. Ipswich ...	Prof. R. Owen, M.D., F.R.S.	Distinction between Plants and Animals, and their Changes of Form.
	G. B. Airy, F.R.S., Astronomer Royal.	Total Solar Eclipse of July 28, 1851.
1852. Belfast......	Prof. G. G. Stokes, D.C.L., F.R.S.	Recent Discoveries in the properties of Light.
	Colonel Portlock, R.E., F.R.S.	Recent Discovery of Rock-salt at Carrickfergus, and geological and practical considerations connected with it.
1853. Hull.........	Prof. J. Phillips, LL.D., F.R.S., F.G.S.	Some peculiar Phenomena in the Geology and Physical Geography of Yorkshire.
	Robert Hunt, F.R.S.............	The present state of Photography.
1854. Liverpool...	Prof. R. Owen, M.D., F.R.S.	Anthropomorphous Apes.
	Col. E. Sabine, V.P.R.S.	Progress of Researches in Terrestrial Magnetism.
1855. Glasgow ...	Dr. W. B. Carpenter, F.R.S.	Characters of Species.
	Lieut.-Col. H. Rawlinson ...	Assyrian and Babylonian Antiquities and Ethnology.
1856. Cheltenham	Col. Sir H. Rawlinson	Recent Discoveries in Assyria and Babylonia, with the results of Cuneiform Research up to the present time.
	W. R. Grove, F.R.S.............	Correlation of Physical Forces.
1857. Dublin......	Prof. W. Thomson, F.R.S. ...	The Atlantic Telegraph.
	Rev. Dr. Livingstone, D.C.L.	Recent Discoveries in Africa.
1858. Leeds	Prof. J. Phillips, LL.D., F.R.S.	The Ironstones of Yorkshire.
	Prof. R. Owen, M.D., F.R.S.	The Fossil Mammalia of Australia.
1859. Aberdeen...	Sir R. I. Murchison, D.C.L....	The Geology of the Northern Highlands.
	Rev. Dr. Robinson, F.R.S. ...	Electrical Discharges in highly rarefied Media.
1860. Oxford......	Rev. Prof. Walker, F.R.S. ...	Physical Constitution of the Sun.
	Captain Sherard Osborn, R.N.	Arctic Discovery.
1861. Manchester	Prof. W. A. Miller, M.A., F.R.S.	Spectrum Analysis.
	G. B. Airy, F.R.S., Astron. Royal	The late Eclipse of the Sun.
1862. Cambridge	Prof. Tyndall, LL.D., F.R.S.	The Forms and Action of Water.
	Prof. Odling, F.R.S.............	Organic Chemistry.
1863. Newcastle	Prof. Williamson, F.R.S.......	The Chemistry of the Galvanic Battery considered in relation to Dynamics.
	James Glaisher, F.R.S.........	The Balloon Ascents made for the British Association.
1864. Bath.........	Prof. Roscoe, F.R.S.............	The Chemical Action of Light.
	Dr. Livingstone, F.R.S.	Recent Travels in Africa.

Date and Place	Lecturers	Subject of Discourse
1865. Birmingham.	J. Beete Jukes, F.R.S.	Probabilities as to the position and extent of the Coal-measures beneath the red rocks of the Midland Counties.
1866. Nottingham	William Huggins, F.R.S.	The Results of Spectrum Analysis applied to Heavenly Bodies.
	Dr. J. D. Hooker, F.R.S.	Insular Floras.
1867. Dundee......	Archibald Geikie, F.R.S.	The Geological Origin of the present Scenery of Scotland.
	Alexander Herschel, F.R.A.S.	The present state of Knowledge regarding Meteors and Meteorites.
1868. Norwich ...	J. Fergusson, F.R.S.	Archæology of the early Buddhist Monuments.
	Dr. W. Odling, F.R.S.	Reverse Chemical Actions.
1869. Exeter	Prof. J. Phillips, LL.D., F.R.S.	Vesuvius.
	J. Norman Lockyer, F.R.S. ..	The Physical Constitution of the Stars and Nebulæ.
1870. Liverpool...	Prof. J. Tyndall, LL.D., F.R.S.	The Scientific Use of the Imagination.
	Prof. W. J. Macquorn Rankine, LL.D., F.R.S.	Stream-lines and Waves, in connection with Naval Architecture.
1871. Edinburgh	F. A. Abel, F.R.S.	Some Recent Investigations and Applications of Explosive Agents.
	E. B. Tylor, F.R.S.	The Relation of Primitive to Modern Civilisation.
1872. Brighton ...	Prof. P. Martin Duncan, M.B., F.R.S.	Insect Metamorphosis.
	Prof. W. K. Clifford	The Aims and Instruments of Scientific Thought.
1873. Bradford ...	Prof. W. C. Williamson, F.R.S.	Coal and Coal Plants.
	Prof. Clerk Maxwell, F.R.S.	Molecules.
1874. Belfast......	Sir John Lubbock, Bart., M.P., F.R.S.	Common Wild Flowers considered in relation to Insects.
	Prof. Huxley, F.R.S.	The Hypothesis that Animals are Automata, and its History.
1875. Bristol	W. Spottiswoode, LL.D., F.R.S.	The Colours of Polarised Light.
	F. J. Bramwell, F.R.S.	Railway Safety Appliances.
1876. Glasgow ...	Prof. Tait, F.R.S.E.	Force.
	Sir Wyville Thomson, F.R.S.	The 'Challenger' Expedition.
1877. Plymouth...	W. Warington Smyth, M.A., F.R.S.	Physical Phenomena connected with the Mines of Cornwall and Devon.
	Prof. Odling, F.R.S.	The New Element, Gallium.
1878. Dublin	G. J. Romanes, F.L.S.	Animal Intelligence.
	Prof. Dewar, F.R.S.	Dissociation, or Modern Ideas of Chemical Action.
1879. Sheffield ...	W. Crookes, F.R.S.	Radiant Matter.
	Prof. E. Ray Lankester, F.R.S.	Degeneration.
1880. Swansea ...	Prof. W. Boyd Dawkins, F.R.S.	Primeval Man.
	Francis Galton, F.R.S.	Mental Imagery.
1881. York.........	Prof. Huxley, Sec. R.S.	The Rise and Progress of Palæontology.
	W. Spottiswoode, Pres. R.S....	The Electric Discharge: its Forms and its Functions.
1882. Southampton.	Prof. Sir Wm. Thomson, F.R.S.	Tides.
	Prof. H. N. Moseley, F.R.S.	Pelagic Life.
1883. Southport...	Prof. R. S. Ball, F.R.S.	Recent Researches on the Distance of the Sun.
	Prof. J. G. McKendrick.	Galvanic and Animal Electricity.

Date and Place	Lecturers	Subject of Discourse
1884. Montreal...	Prof. O. J. Lodge, D.Sc.	Dust.
	Rev. W. H. Dallinger, F.R.S.	The Modern Microscope in Researches on the Least and Lowest Forms of Life.
1885. Aberdeen...	Prof. W. G. Adams, F.R.S. ...	The Electric Light and Atmospheric Absorption.
	John Murray, F.R.S.E.........	The Great Ocean Basins.
1886. Birmingham.	A. W. Rücker, M.A., F.R.S.	Soap Bubbles.
	Prof. W. Rutherford, M.D. ...	The Sense of Hearing.
1887. Manchester	Prof. H. B. Dixon, F.R.S. ...	The Rate of Explosions in Gases.
	Col. Sir F. de Winton	Explorations in Central Africa.
1888. Bath.........	Prof. W. E. Ayrton, F.R.S. ...	The Electrical Transmission of Power.
	Prof. T. G. Bonney, D.Sc., F.R.S.	The Foundation Stones of the Earth's Crust.
1889. Newcastle-upon-Tyne	Prof. W. C. Roberts-Austen, F.R.S.	The Hardening and Tempering of Steel.
	Walter Gardiner, M.A.........	How Plants maintain themselves in the Struggle for Existence.
1890. Leeds	E. B. Poulton, M.A., F.R.S....	Mimicry.
	Prof. C. Vernon Boys, F.R.S.	Quartz Fibres and their Applications.
1891. Cardiff	Prof. L. C. Miall, F.L.S., F.G.S.	Some Difficulties in the Life of Aquatic Insects.
	Prof. A. W. Rücker, M.A., F.R.S.	Electrical Stress.
1892. Edinburgh	Prof. A. M. Marshall, F.R.S.	Pedigrees.
	Prof. J. A. Ewing, M.A., F.R.S.	Magnetic Induction.
1893. Nottingham	Prof. A. Smithells, B.Sc.	Flame.
	Prof. Victor Horsley, F.R.S.	The Discovery of the Physiology of the Nervous System.
1894. Oxford......	J. W. Gregory, D.Sc., F.G.S.	Experiences and Prospects of African Exploration.
	Prof. J. Shield Nicholson, M.A.	Historical Progress and Ideal Socialism.
1895. Ipswich ...	Prof. S. P. Thompson, F.R.S.	Magnetism in Rotation.
	Prof. Percy F. Frankland, F.R.S.	The Work of Pasteur and its various Developments.
1896. Liverpool...	Dr. F. Elgar, F.R.S.	Safety in Ships.
	Prof. Flinders Petrie, D.C.L.	Man before Writing.
1897. Toronto ...	Prof. W. C. Roberts-Austen, F.R.S.	Canada's Metals.
	J. Milne, F.R.S..................	Earthquakes and Volcanoes.
1898. Bristol......	Prof. W. J. Sollas, F.R.S.	Funafuti: the Study of a Coral Island.
	Herbert Jackson	Phosphorescence.
1899. Dover	Prof. Charles Richet............	La vibration nerveuse.
	Prof. J. Fleming, F.R.S.	The Centenary of the Electric Current.
1900. Bradford ...	Prof. F. Gotch, F.R.S..........	Animal Electricity.
	Prof. W. Stroud.	Range Finders.
1901. Glasgow ...	Prof. W. Ramsay, F.R.S	The Inert Constituents of the Atmosphere.
	Francis Darwin, F.R.S.	The Movements of Plants.
1902. Belfast ...	Prof. J. J. Thomson, F.R.S....	Becquerel Rays and Radio-activity.
	Prof. W. F. R. Weldon, F.R.S.	Inheritance.
1903. Southport...	Dr. R. Munro	Man as Artist and Sportsman in the Palæolithic Period.
	Dr. A. Rowe	The Old Chalk Sea, and some of its Teachings.
1904. Cambridge	Prof. G. H. Darwin, F.R.S....	Ripple-Marks and Sand-Dunes.
	Prof. H. F. Osborn	Palæontological Discoveries in the Rocky Mountains.

Date and Place	Lecturers	Subject of Discourse
1905. South Africa: Cape Town	Prof. E. B. Poulton, F.R.S.	W. J. Burchell's Discoveries in South Africa.
	C. Vernon Boys, F.R.S.	Some Surface Actions of Fluids.
Durban	Douglas W. Freshfield	The Mountains of the Old World.
	Prof. W. A. Herdman, F.R.S.	Marine Biology.
Pietermaritzburg.	Col. D. Bruce, C.B., F.R.S.	Sleeping Sickness.
	H. T. Ferrar	The Cruise of the 'Discovery.'
Johannesburg	Prof. W. E. Ayrton, F.R.S.	The Distribution of Power.
	Prof. J. O. Arnold	Steel as an Igneous Rock.
Pretoria	A. E. Shipley, F.R.S.	Fly-borne Diseases: Malaria, Sleeping Sickness, &c.
Bloemfontein	A. R. Hinks	The Milky Way and the Clouds of Magellan.
Kimberley	Sir Wm. Crookes, F.R.S.	Diamonds.
	Prof. J. B. Porter	The Bearing of Engineering on Mining.
Bulawayo	D. Randall-MacIver	The Ruins of Rhodesia.
1906. York	Dr. Tempest Anderson	Volcanoes.
	Dr. A. D. Waller, F.R.S.	The Electrical Signs of Life, and their Abolition by Chloroform.
1907. Leicester	W. Duddell, F.R.S.	The Ark and the Spark in Radiotelegraphy.
	Dr. F. A. Dixey	Recent Developments in the Theory of Mimicry.
1908. Dublin	Prof. H. H. Turner, F.R.S.	Halley's Comet.
	Prof. W. M. Davis	The Lessons of the Colorado Canyon.
1909. Winnipeg	Dr. A. E. H. Tutton, F.R.S.	The Seven Styles of Crystal Architecture.
	Prof. W. A. Herdman, F.R.S.	Our Food from the Waters.
	[1] Prof. H. B. Dixon, F.R.S.	The Chemistry of Flame.
	[1] Prof. J. H. Poynting, F.R.S.	The Pressure of Light.
1910. Sheffield	Prof. W. Stirling, M.D.	Types of Animal Movement.[2]
	D. G. Hogarth	New Discoveries about the Hittites.
1911. Portsmouth	Dr. Leonard Hill, F.R.S.	The Physiology of Submarine Work.
	Prof. A. C. Seward, F.R.S.	Links with the Past in the Plant World.

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[1] 'Popular Lectures,' delivered to the citizens of Winnipeg.

[2] Repeated, to the public, on Wednesday, September 7.

LECTURES TO THE OPERATIVE CLASSES.

Date and Place	Lecturers	Subject of Lecture
1867. Dundee......	Prof. J. Tyndall, LL.D., F.R.S.	Matter and Force.
1868. Norwich ...	Prof. Huxley, LL.D., F.R.S.	A Piece of Chalk.
1869. Exeter	Prof. Miller, M.D., F.R.S. ...	The modes of detecting the Composition of the Sun and other Heavenly Bodies by the Spectrum.
1870. Liverpool...	Sir John Lubbock, Bart., F.R.S.	Savages.
1872. Brighton ...	W. Spottiswoode, LL.D., F.R.S.	Sunshine, Sea, and Sky.
1873. Bradford ...	C. W. Siemens, D.C.L., F.R.S.	Fuel.
1874. Belfast	Prof. Odling, F.R.S.	The Discovery of Oxygen.
1875. Bristol	Dr. W. B. Carpenter, F.R.S.	A Piece of Limestone.
1876. Glasgow ...	Commander Cameron, C.B....	A Journey through Africa.
1877. Plymouth...	W. H. Preece......................	Telegraphy and the Telephone.
1879. Sheffield ...	W. E. Ayrton	Electricity as a Motive Power
1880. Swansea ...	H. Seebohm, F.Z.S.	The North-East Passage.
1881. York	Prof. Osborne Reynolds, F.R.S.	Raindrops, Hailstones, and Snowflakes.
1882. Southampton.	Dr. John Evans, Treas. R.S.	Unwritten History, and how to read it.
1883. Southport...	Sir F. J. Bramwell, F.R.S. ...	Talking by Electricity—Telephones.
1884. Montreal ...	Prof. R. S. Ball, F.R.S..........	Comets.
1885. Aberdeen...	H. B. Dixon, M.A.	The Nature of Explosions.
1886. Birmingham	Prof. W. C. Roberts-Austen, F.R.S.	The Colours of Metals and their Alloys.
1887. Manchester	Prof. G. Forbes, F.R.S.	Electric Lighting.
1888. Bath.........	Sir John Lubbock, Bart., F.R.S.	The Customs of Savage Races.
1889. Newcastle-upon-Tyne	B. Baker, M.Inst.C.E.	The Forth Bridge.
1890. Leeds	Prof. J. Perry, D.Sc., F.R.S.	Spinning Tops.
1891. Cardiff......	Prof. S. P. Thompson, F.R.S.	Electricity in Mining.
1892. Edinburgh..	Prof. C. Vernon Boys, F.R.S.	Electric Spark Photographs.
1893. Nottingham	Prof. Vivian B. Lewes	Spontaneous Combustion.
1894. Oxford......	Prof. W. J. Sollas, F.R.S. ...	Geologies and Deluges.
1895. Ipswich ...	Dr. A. H. Fison...	Colour.
1896. Liverpool...	Prof. J. A. Fleming, F.R.S....	The Earth a Great Magnet.
1897. Toronto ...	Dr. H. O. Forbes	New Guinea.
1898. Bristol......	Prof. E. B. Poulton, F.R.S. ...	The ways in which Animals Warn their Enemies and Signal to their Friends.
1900. Bradford...	Prof. S. P. Thompson, F.R.S.	Electricity in the Industries.
1901. Glasgow ...	H. J. Mackinder, M.A..........	The Movements of Men by Land and Sea.
1902. Belfast......	Prof. L. C. Miall, F.R.S.	Gnats and Mosquitoes.
1903. Southport...	Dr. J. S. Flett	Martinique and St. Vincent: the Eruptions of 1902.
1904. Cambridge..	Dr. J. E. Marr, F.R.S.	The Forms of Mountains.
1906. York.........	Prof. S. P. Thompson, F.R.S.	The Manufacture of Light.
1907. Leicester...	Prof. H. A. Miers, F.R.S.......	The Growth of a Crystal.
1908. Dublin......	Dr. A. E. H. Tutton, F.R.S.	The Crystallisation of Water.
1910. Sheffield ...	C. T. Heycock, F.R.S.	Metallic Alloys.
1911. Portsmouth	Dr. H. R. Mill	Rain.

Table showing the Attendances and Receipts

Date of Meeting	Where held	Presidents	Old Life Members	New Life Members
1831, Sept. 27	York	Viscount Milton, D.C.L., F.R.S.	—	—
1832, June 19	Oxford	The Rev. W. Buckland, F.R.S.	—	—
1833, June 25	Cambridge	The Rev. A. Sedgwick, F.R.S.	—	—
1834, Sept. 8	Edinburgh	Sir T. M. Brisbane, D.C.L., F.R.S.	—	—
1835, Aug. 10	Dublin	The Rev. Provost Lloyd, LL.D., F.R.S.	—	—
1836, Aug. 22	Bristol	The Marquis of Lansdowne, F.R.S.	—	—
1837, Sept. 11	Liverpool	The Earl of Burlington, F.R.S.	—	—
1838, Aug. 10	Newcastle-on-Tyne	The Duke of Northumberland, F.R.S.	—	—
1839, Aug. 26	Birmingham	The Rev. W. Vernon Harcourt, F.R.S.	—	—
1840, Sept. 17	Glasgow	The Marquis of Breadalbane, F.R.S.	—	—
1841, July 20	Plymouth	The Rev. W. Whewell, F.R.S.	169	65
1842, June 23	Manchester	The Lord Francis Egerton, F.G.S.	303	169
1843, Aug. 17	Cork	The Earl of Rosse, F.R.S.	109	28
1844, Sept. 26	York	The Rev. G. Peacock, D.D., F.R.S.	226	150
1845, June 19	Cambridge	Sir John F. W. Herschel, Bart., F.R.S.	313	36
1846, Sept. 10	Southampton	Sir Roderick I. Murchison, Bart., F.R.S.	241	10
1847, June 23	Oxford	Sir Robert H. Inglis, Bart., F.R.S.	314	18
1848, Aug. 9	Swansea	The Marquis of Northampton, Pres. R.S.	149	* 3
1849, Sept. 12	Birmingham	The Rev. T. R. Robinson, D.D., F.R.S.	227	12
1850, July 21	Edinburgh	Sir David Brewster, K.H., F.R.S.	235	9
1851, July 2	Ipswich	G. B. Airy, Astronomer Royal, F.R.S.	172	8
1852, Sept. 1	Belfast	Lieut.-General Sabine, F.R.S.	164	10
1853, Sept. 3	Hull	William Hopkins, F.R.S.	141	13
1854, Sept. 20	Liverpool	The Earl of Harrowby, F.R.S.	238	23
1855, Sept. 12	Glasgow	The Duke of Argyll, F.R.S.	194	33
1856, Aug. 6	Cheltenham	Prof. C. G. B. Daubeny, M.D., F.R.S.	182	14
1857, Aug. 26	Dublin	The Rev. H. Lloyd, D.D., F.R.S.	236	15
1858, Sept. 22	Leeds	Richard Owen, M.D., D.C.L., F.R.S.	222	42
1859, Sept. 14	Aberdeen	H.R.H. The Prince Consort	184	27
1860, June 27	Oxford	The Lord Wrottesley, M.A., F.R.S.	286	21
1861, Sept. 4	Manchester	William Fairbairn, LL.D., F.R.S.	321	113
1862, Oct. 1	Cambridge	The Rev. Professor Willis, M.A., F.R.S.	239	15
1863, Aug. 26	Newcastle-on-Tyne	Sir William G. Armstrong, C.B., F.R.S.	203	36
1864, Sept. 13	Bath	Sir Charles Lyell, Bart., M.A., F.R.S.	287	40
1865, Sept. 6	Birmingham	Prof. J. Phillips, M.A., LL.D., F.R.S.	292	44
1866, Aug. 22	Nottingham	William R. Grove, Q.C., F.R.S.	207	31
1867, Sept. 4	Dundee	The Duke of Buccleuch, K.C.B., F.R.S.	167	25
1868, Aug. 19	Norwich	Dr. Joseph D. Hooker, F.R.S.	196	18
1869, Aug. 18	Exeter	Prof. G. G. Stokes, D.C.L., F.R.S.	204	21
1870, Sept. 14	Liverpool	Prof. T. H. Huxley, LL.D., F.R.S.	314	39
1871, Aug. 2	Edinburgh	Prof. Sir W. Thomson, LL.D., F.R.S.	246	28
1872, Aug. 14	Brighton	Dr. W. B. Carpenter, F.R.S.	245	36
1873, Sept. 17	Bradford	Prof. A. W. Williamson, F.R.S.	212	27
1874, Aug. 19	Belfast	Prof. J. Tyndall, LL.D., F.R.S.	162	13
1875, Aug. 25	Bristol	Sir John Hawkshaw, F.R.S.	239	36
1876, Sept. 6	Glasgow	Prof. T. Andrews, M.D., F.R.S.	221	35
1877, Aug. 15	Plymouth	Prof. A. Thomson, M.D., F.R.S.	173	19
1878, Aug. 14	Dublin	W. Spottiswoode, M.A., F.R.S.	201	18
1879, Aug. 20	Sheffield	Prof. G. J. Allman, M.D., F.R.S.	184	16
1880, Aug. 25	Swansea	A. C. Ramsay, LL.D., F.R.S.	144	11
1881, Aug. 31	York	Sir John Lubbock, Bart., F.R.S.	272	28
1882, Aug. 23	Southampton	Dr. C. W. Siemens, F.R.S.	178	17
1883, Sept. 19	Southport	Prof. A. Cayley, D.C.L., F.R.S.	203	60
1884, Aug. 27	Montreal	Prof. Lord Rayleigh, F.R.S.	235	20
1885, Sept. 9	Aberdeen	Sir Lyon Playfair, K.C.B., F.R.S.	225	18
1886, Sept. 1	Birmingham	Sir J. W. Dawson, C.M.G., F.R.S.	314	25
1887, Aug. 31	Manchester	Sir H. E. Roscoe, D.C.L., F.R.S.	428	86
1888, Sept. 5	Bath	Sir F. J. Bramwell, F.R.S.	266	36
1889, Sept. 11	Newcastle-on-Tyne	Prof. W. H. Flower, C.B., F.R.S.	277	20
1890, Sept. 3	Leeds	Sir F. A. Abel, C.B., F.R.S.	259	21
1891, Aug. 19	Cardiff	Dr. W. Huggins, F.R.S.	189	24
1892, Aug. 3	Edinburgh	Sir A. Geikie, LL.D., F.R.S.	280	14
1893, Sept. 13	Nottingham	Prof. J. S. Burdon Sanderson, F.R.S.	201	17
1894, Aug. 8	Oxford	The Marquis of Salisbury, K.G., F.R.S.	327	21
1895, Sept. 11	Ipswich	Sir Douglas Galton, K.C.B., F.R.S.	214	13
1896, Sept. 16	Liverpool	Sir Joseph Lister, Bart., Pres. R.S.	330	31
1897, Aug. 18	Toronto	Sir John Evans, K.C.B., F.R.S.	120	8
1898, Sept. 7	Bristol	Sir W. Crookes, F.R.S.	281	19
1899, Sept. 13	Dover	Sir Michael Foster, K.C.B., Sec. R.S.	296	20
1900, Sept. 5	Bradford	Sir William Turner, D.C.L., F.R.S.	267	13
1901, Sept. 11	Glasgow	Prof. A. W. Rücker, D.Sc., Sec. R.S.	310	37
1902, Sept. 10	Belfast	Prof. J. Dewar, LL.D., F.R.S.	243	21
1903, Sept. 9	Southport	Sir Norman Lockyer, K.C.B., F.R.S.	250	21
1904, Aug. 17	Cambridge	Rt. Hon. A. J. Balfour, M.P., F.R.S.	419	32
1905, Aug. 15	South Africa	Prof. G. H. Darwin, LL.D., F.R.S.	115	40
1906, Aug. 1	York	Prof. E. Ray Lankester, LL.D., F.R.S.	322	10
1907, July 31	Leicester	Sir David Gill, K.C.B., F.R.S.	276	19
1908, Sept. 2	Dublin	Dr. Francis Darwin, F.R.S.	294	24
1909, Aug. 25	Winnipeg	Prof. Sir J. J. Thomson, F.R.S.	117	13
1910, Aug. 31	Sheffield	Rev. Prof. T. G. Bonney, F.R.S.	293	26
1911, Aug. 30	Portsmouth	Prof. Sir W. Ramsay, K.C.B., F.R.S.	284	21

* Ladies were not admitted by purchased tickets until 1843. † Tickets of Admission to Sections only.
¶ Including 848 Members of the South African Association.

at Annual Meetings of the Association.

Old Annual Members	New Annual Members	Associates	Ladies	Foreigners	Total	Amount received during the Meeting	Sums paid on account of Grants for Scientific Purposes	Year
—	—	—	—	—	353	—	—	1831
—	—	—	—	—	—	—	—	1832
—	—	—	—	—	900	—	—	1833
—	—	—	—	—	1298	—	£20 0 0	1834
—	—	—	—	—	—	—	167 0 0	1835
—	—	—	—	—	1350	—	435 0 0	1836
—	—	—	—	—	1840	—	922 12 6	1837
—	—	—	1100*	—	2400	—	932 2 2	1838
—	—	—	—	34	1438	—	1595 11 0	1839
—	—	—	—	40	1353	—	1546 16 4	1840
46	317	—	60*	—	891	—	1235 10 11	1841
75	376	33†	331*	28	1315	—	1449 17 8	1842
71	185	—	160	—	—	—	1565 10 2	1843
45	190	9†	260	—	—	—	981 12 8	1844
94	22	407	172	35	1079	—	831 9 9	1845
65	39	270	196	36	857	—	685 16 0	1846
197	40	495	203	53	1320	—	208 5 4	1847
54	25	376	197	15	819	£707 0 0	275 1 8	1848
93	33	447	237*	22	1071	963 0 0	159 19 6	1849
128	42	510	273	44	1241	1085 0 0	345 18 0	1850
61	47	244	141	37	710	620 0 0	391 9 7	1851
63	60	510	292	9	1108	1085 0 0	304 6 7	1852
56	57	367	236	6	876	903 0 0	205 0 0	1853
121	121	765	524	10	1802	1882 0 0	380 19 7	1854
142	101	1094	543	26	2133	2311 0 0	480 16 4	1855
104	48	412	346	9	1115	1098 0 0	734 13 9	1856
156	120	900	569	26	2022	2015 0 0	507 15 4	1857
111	91	710	509	13	1698	1931 0 0	618 18 2	1858
125	179	1206	821	22	2564	2782 0 0	684 11 1	1859
177	59	636	463	47	1689	1604 0 0	766 19 6	1860
184	125	1589	791	15	3138	3944 0 0	1111 5 10	1861
150	57	433	242	25	1161	1089 0 0	1293 16 6	1862
154	209	1704	1004	25	3335	3640 0 0	1608 3 10	1863
182	103	1119	1058	13	2802	2965 0 0	1289 15 8	1864
215	149	766	508	23	1997	2227 0 0	1591 7 10	1865
218	105	960	771	11	2303	2469 0 0	1750 13 4	1866
193	118	1163	771	7	2444	2613 0 0	1739 4 0	1867
226	117	720	682	45‡	2004	2042 0 0	1940 0 0	1868
229	107	678	600	17	1856	1931 0 0	1622 0 0	1869
303	195	1103	910	14	2878	3096 0 0	1572 0 0	1870
311	127	976	754	21	2463	2575 0 0	1472 2 6	1871
280	80	937	912	43	2533	2649 0 0	1285 0 0	1872
237	99	796	601	11	1983	2120 0 0	1685 0 0	1873
232	85	817	630	12	1951	1979 0 0	1151 16 0	1874
307	93	884	672	17	2248	2397 0 0	960 0 0	1875
331	185	1265	712	25	2774	3023 0 0	1092 4 2	1876
238	59	446	283	11	1229	1268 0 0	1128 9 7	1877
290	93	1285	674	17	2578	2615 0 0	725 16 6	1878
239	74	529	349	13	1404	1425 0 0	1080 11 11	1879
171	41	389	147	12	915	899 0 0	731 7 7	1880
313	176	1230	514	24	2557	2689 0 0	476 8 1	1881
253	79	516	189	21	1253	1286 0 0	1126 1 11	1882
330	323	952	841	5	2714	3369 0 0	1083 3 3	1883
317	219	826	74	26 & 60 H.§	1777	1855 0 0	1173 4 0	1884
332	122	1053	447	6	2203	2256 0 0	1385 0 0	1885
428	179	1067	429	11	2453	2532 0 0	995 0 6	1886
510	244	1985	493	92	3838	4336 0 0	1186 18 0	1887
399	100	639	509	12	1984	2107 0 0	1511 0 5	1888
412	113	1024	579	21	2437	2441 0 0	1417 0 11	1889
368	92	680	334	12	1775	1776 0 0	789 16 8	1890
341	152	672	107	35	1497	1664 0 0	1029 10 0	1891
413	141	733	439	50	2070	2007 0 0	864 10 0	1892
328	57	773	268	17	1661	1653 0 0	907 15 6	1893
435	69	941	451	77	2321	2175 0 0	583 15 6	1894
290	31	493	261	22	1324	1236 0 0	977 15 5	1895
383	139	1384	873	41	3181	3228 0 0	1104 6 1	1896
286	125	682	100	41	1362	1398 0 0	1059 10 8	1897
327	96	1051	639	33	2446	2399 0 0	1212 0 0	1898
324	68	548	120	27	1403	1328 0 0	1430 14 2	1899
297	45	801	482	9	1915	1801 0 0	1072 10 0	1900
374	131	794	246	20	1912	2046 0 0	945 0 0	1901
314	86	647	305	6	1620	1644 0 0	947 0 0	1902
319	90	698	365	21	1754	1762 0 0	845 13 2	1903
449	113	1338	317	121	2789	2650 0 0	887 18 11	1904
937¶	411	430	181	16	2130	2422 0 0	928 2 2	1905
356	93	817	352	22	1972	1811 0 0	882 0 9	1906
339	61	659	251	42	1647	1561 0 0	757 12 10	1907
465	112	1166	222	14	2297	2317 0 0	1157 18 8	1908
290**	162	789	90	7	1468	1623 0 0	1014 9 9	1909
379	57	563	123	8	1449	1439 0 0	963 17 0	1910
349	61	414	81	31	1241	1176 0 0	922 0 0	1911

‡ Including Ladies. § Fellows of the American Association were admitted as Hon. Members for this Meeting.
** Including 137 Members of the American Association.

ANALYSIS OF ATTENDANCES AT THE ANNUAL MEETINGS, 1831 1910.

[*The total attendances for the years* 1832, 1835, 1843, *and* 1844 *are unknown.*]

Average attendance at 76 Meetings : 1848.

	Average Attendance
Average attendance at 5 Meetings beginning during *June, between* 1833 *and* 1860	1260
Average attendance at 4 Meetings beginning during *July, between* 1841 *and* 1907	1122
Average attendance at 30 Meetings beginning during *August, between* 1836 *and* 1910	1913[1]
Average attendance at 35 Meetings beginning during *September, between* 1831 *and* 1908	1914
Attendance at 1 Meeting held in *October, Cambridge*, 1862	1161

◆

Meetings beginning during August and September.

Average attendance at —

4	Meetings beginning during the 1st week in *August*	(1st- 7th)	.	1905
5	" " " " 2nd " " "	(8th-14th)	.	2130
8	" " " " 3rd " " "	(15th-21st)	.	1761[2]
13	" " " " 4th " " "	(22nd 31st)	.	1996

Average attendance at—

12	Meetings beginning during the 1st week in *September*	(1st- 7th)	.	2100
16	" " " " 2nd " " "	(8th-14th)	.	1860
5	" " " " 3rd " " "	(15th-21st)	.	2206
2	" " " " 4th " " "	(22nd-30th)	.	1025

Meetings beginning during June, July, and October.

Attendance at 1 Meeting (1845, June 19) beginning during the 3rd week in *June* (15th-21st)	1079
Average attendance at 4 Meetings beginning during the 4th week in *June* (22nd-30th)	1306
Attendance at 1 Meeting (1851, July 2) beginning during the 1st week in *July* (1st-7th)	710
Average attendance at 2 Meetings beginning during the 3rd week in *July* (15th-21st)	1066
Attendance at 1 Meeting (1907, July 31) beginning during the 5th week in *July* (29th-31st)	1647
Attendance at 1 Meeting (1862, October 1) beginning during the 1st week in *October* (1st-7th)	1161

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[1] **Average attendance at 31 Meetings, *including* South Africa, 1905 (August 15-September 1): 1949.**

[2] **Average attendance at 9 Meetings, *including* South Africa, 1905 (August 15-September 1): 1802.**

General Statement of Sums which have been paid on account of Grants for Scientific Purposes.

1834.

	£	s.	d.
Tide Discussions	20	0	0

1835.

	£	s.	d.
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0

1836.

	£	s.	d.
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on Long-continued Heat	17	1	0
Rain-gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£435	0	0

1837.

	£	s.	d.
Tide Discussions	284	1	0
Chemical Constants	24	13	6
Lunar Nutation	70	0	0
Observations on Waves	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature	93	3	0
Vitrification Experiments	150	0	0
Heart Experiments	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£922	12	6

1838.

	£	s.	d.
Tide Discussions	29	0	0
British Fossil Fishes	100	0	0
Meteorological Observations and Anemometer Construction	100	0	0
Strength of Cast Iron	60	0	0
Preservation of Animal and Vegetable Substances	19	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee	50	0	0
Heart Experiments	5	3	0
Land and Sea Level	267	8	7
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
	£932	2	2

1839.

	£	s.	d.
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth, &c.	63	10	0
Mechanism of Waves	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature	21	11	0
Vitrification Experiments	9	4	0
Cast-iron Experiments	103	0	7
Railway Constants	28	7	0
Land and Sea Level	274	1	2
Steam-vessels' Engines	100	0	4
Stars in Histoire Céleste	171	18	0
Stars (Lacaille)	11	0	6
Stars in R.A.S. Catalogue	166	16	0
Animal Secretions	10	10	6
Steam Engines in Cornwall	50	0	0
Atmospheric Air	16	1	0
Cast and Wrought Iron	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics	50	0	0
	£1595	11	0

1840.

	£	s.	d.
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments	18	19	0
Lungs Experiments	8	13	0
Tide Discussions	50	0	0
Land and Sea Level	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air	15	15	0
Water on Iron	10	0	0
Heat on Organic Bodies	7	0	0
Meteorological Observations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phenomena	40	0	0
Meteorological Observations at Plymouth	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4

1841.

	£	s.	d.
Observations on Waves	30	0	0
Meteorology and Subterranean Temperature	8	8	0
Actinometers	10	0	0
Earthquake Shocks	17	7	0
Acrid Poisons	6	0	0
Veins and Absorbents	3	0	0
Mud in Rivers	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers	6	18	6
Stars (Histoire Céleste)	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of)	40	0	0
Water on Iron	50	0	0
Meteorological Observations at Inverness	20	0	0
Meteorological Observations (reduction of)	25	0	0
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	6
Railway Sections	38	1	0
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth	55	0	0
Magnetical Observations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men	5	0	0
Radiate Animals	2	0	0
	£1235	10	11

1842.

	£	s.	d.
Dynamometric Instruments	113	11	2
Anoplura Britanniæ	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (Brit. Assoc. Cat. of)	110	0	0
Railway Sections	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth	68	0	0
Constant Indicator and Dynamometric Instruments	90	0	0
Force of Wind	10	0	0
Light on Growth of Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Firth of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture, and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological Operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8

	£	s.	d.
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Experiments on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland ...	100	0	0
Revision of the Nomenclature of Stars 1842	2	9	6
Maintaining the Establishment at Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes 1842	23	11	10
Structure of Fossil Shells......	20	0	0
Radiata and Mollusca of the Ægean and Red Seas 1842	100	0	0
Geographical Distributions of Marine Zoology 1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds 1842	8	7	3
Exotic Anoplura	15	0	0
Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the Internal Constitution of Metals......	50	0	0
Constant Indicator and Morin's Instrument.........1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Meteorological Instruments at Edinburgh................	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment at Kew Observatory	149	15	0
For Kreil's Barometrograph...	25	0	0
Gases from Iron Furnaces ...	50	0	0
The Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura 1843	10	0	0
Vitality of Seeds 1843	2	0	7
Vitality of Seeds 1844	7	0	0
Marine Zoology of Cornwall...	10	0	0
Physiological Action of Medicines..............................	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Earthquake Shocks 1843	15	14	8
	£831	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars 1844	211	15	0
Fossil Fishes of the London Clay............................	100	0	0
Computation of the Gaussian Constants for 1829	50	0	0
Maintaining the Establishment at Kew Observatory. .	146	16	7
Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds 1844	2	15	10
Vitality of Seeds 1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Marine Zoology of Britain ...	10	0	0
Exotic Anoplura 1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Atmospheric Waves	3	3	3
Captive Balloons 1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality in York	12	0	0
	£685	16	0

1847.

	£	s.	d.
Computation of the Gaussian Constants for 1829	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	1

1848.

Maintaining the Establishment at Kew Observatory	171	15	11
Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogue of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8

1849.

Electrical Observations at Kew Observatory	50	0	0
Maintaining the Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phenomena	10	0	0
Bill on Account of Anemometrical Observations	13	9	0
	£159	19	6

1850.

Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phenomena	15	0	0
Meteorological Instruments, Azores	25	0	0
	£345	18	0

1851.

Maintaining the Establishment at Kew Observatory (including part of grant in 1849)	309	2	2
Theory of Heat	20	1	1
Periodical Phenomena of Animals and Plants	5	0	0
Vitality of Seeds	5	6	4
Influence of Solar Radiation	30	0	0
Ethnological Inquiries	12	0	0
Researches on Annelida	10	0	0
	£391	9	7

1852.

	£	s.	d.
Maintaining the Establishment at Kew Observatory (including balance of grant for 1850)	233	17	8
Experiments on the Conduction of Heat	5	2	9
Influence of Solar Radiations	20	0	0
Geological Map of Ireland	15	0	0
Researches on the British Annelida	10	0	0
Vitality of Seeds	10	6	2
Strength of Boiler Plates	10	0	0
	£304	6	7

1853

Maintaining the Establishment at Kew Observatory	165	0	0
Experiments on the Influence of Solar Radiation	15	0	0
Researches on the British Annelida	10	0	0
Dredging on the East Coast of Scotland	10	0	0
Ethnological Queries	5	0	0
	£205	0	0

1854.

Maintaining the Establishment at Kew Observatory (including balance of former grant)	330	15	4
Investigations on Flax	11	0	0
Effects of Temperature on Wrought Iron	10	0	0
Registration of Periodical Phenomena	10	0	0
British Annelida	10	0	0
Vitality of Seeds	5	2	3
Conduction of Heat	4	2	0
	£380	19	7

1855.

Maintaining the Establishment at Kew Observatory	425	0	0
Earthquake Movements	10	0	0
Physical Aspect of the Moon	11	8	5
Vitality of Seeds	10	7	11
Map of the World	15	0	0
Ethnological Queries	5	0	0
Dredging near Belfast	4	0	0
	£480	16	4

1856.

Maintaining the Establishment at Kew Observatory:— 1854 £75 0 0 1855 £500 0 0	575	0	0

	£	s.	d.
Strickland's Ornithological Synonyms	100	0	0
Dredging and Dredging Forms	9	13	9
Chemical Action of Light	20	0	0
Strength of Iron Plates	10	0	0
Registration of Periodical Phenomena	10	0	0
Propagation of Salmon	10	0	0
	£734	13	9

1857.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	350	0	0
Earthquake Wave Experiments	40	0	0
Dredging near Belfast	10	0	0
Dredging on the West Coast of Scotland	10	0	0
Investigations into the Mollusca of California	10	0	0
Experiments on Flax	5	0	0
Natural History of Madagascar	20	0	0
Researches on British Annelida	25	0	0
Report on Natural Products imported into Liverpool	10	0	0
Artificial Propagation of Salmon	10	0	0
Temperature of Mines	7	8	0
Thermometers for Subterranean Observations	5	7	4
Life-boats	5	0	0
	£507	15	4

1858.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Wave Experiments	25	0	0
Dredging on the West Coast of Scotland	10	0	0
Dredging near Dublin	5	0	0
Vitality of Seed	5	5	0
Dredging near Belfast	18	13	2
Report on the British Annelida	25	0	0
Experiments on the production of Heat by Motion in Fluids	20	0	0
Report on the Natural Products imported into Scotland	10	0	0
	£618	18	2

1859.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Dublin	15	0	0
Osteology of Birds	50	0	0
Irish Tunicata	5	0	0
Manure Experiments	20	0	0
British Medusidæ	5	0	0
Dredging Committee	5	0	0
Steam-vessels' Performance	5	0	0
Marine Fauna of South and West of Ireland	10	0	0
Photographic Chemistry	10	0	0
Lanarkshire Fossils	20	0	1
Balloon Ascents	39	11	0
	£684	11	1

1860.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Dredging near Belfast	16	6	0
Dredging in Dublin Bay	15	0	0
Inquiry into the Performance of Steam-vessels	124	0	0
Explorations in the Yellow Sandstone of Dura Den	20	0	0
Chemico-mechanical Analysis of Rocks and Minerals	25	0	0
Researches on the Growth of Plants	10	0	0
Researches on the Solubility of Salts	30	0	0
Researches on the Constituents of Manures	25	0	0
Balance of Captive Balloon Accounts	1	13	6
	£766	19	6

1861.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Earthquake Experiments	25	0	0
Dredging North and East Coasts of Scotland	23	0	0
Dredging Committee:— 1860......£50 0 0 1861......£22 0 0	72	0	0
Excavations at Dura Den	20	0	0
Solubility of Salts	20	0	0
Steam-vessel Performance	150	0	0
Fossils of Lesmahagow	15	0	0
Explorations at Uriconium	20	0	0
Chemical Alloys	20	0	0
Classified Index to the Transactions	100	0	0
Dredging in the Mersey and Dee	5	0	0
Dip Circle	30	0	0
Photoheliographic Observations	50	0	0
Prison Diet	20	0	0
Gauging of Water	10	0	0
Alpine Ascents	6	5	10
Constituents of Manures	25	0	0
	£1111	5	10

1862.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	500	0	0
Patent Laws	21	6	0
Mollusca of N.-W. of America	10	0	0
Natural History by Mercantile Marine	5	0	0
Tidal Observations	25	0	0
Photoheliometer at Kew	40	0	0
Photographic Pictures of the Sun	150	0	0
Rocks of Donegal	25	0	0
Dredging Durham and Northumberland Coasts	25	0	0
Connection of Storms	20	0	0
Dredging North-east Coast of Scotland	6	9	6
Ravages of Teredo	3	11	0
Standards of Electrical Resistance	50	0	0
Railway Accidents	10	0	0
Balloon Committee	200	0	0
Dredging Dublin Bay	10	0	0
Dredging the Mersey	5	0	0
Prison Diet	20	0	0
Gauging of Water	12	10	0
Steamships' Performance	150	0	0
Thermo-electric Currents	5	0	0
	£1293	16	6

1863.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee deficiency	70	0	0
Balloon Ascents (other expenses)	25	0	0
Entozoa	25	0	0
Coal Fossils	20	0	0
Herrings	20	0	0
Granites of Donegal	5	0	0
Prison Diet	20	0	0
Vertical Atmospheric Movements	13	0	0
Dredging Shetland	50	0	0
Dredging North-east Coast of Scotland	25	0	0
Dredging Northumberland and Durham	17	3	10
Dredging Committee Superintendence	10	0	0
Steamship Performance	100	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Volcanic Temperature	100	0	0
Bromide of Ammonium	8	0	0
Electrical Standards	100	0	0
Electrical Construction and Distribution	40	0	0
Luminous Meteors	17	0	0
Kew Additional Buildings for Photoheliograph	100	0	0
Thermo-electricity	15	0	0
Analysis of Rocks	8	0	0
Hydroida	10	0	0
	£1608	3	10

1864.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Coal Fossils	20	0	0
Vertical Atmospheric Movements	20	0	0
Dredging, Shetland	75	0	0
Dredging, Northumberland	25	0	0
Balloon Committee	200	0	0
Carbon under pressure	10	0	0
Standards of Electric Resistance	100	0	0
Analysis of Rocks	10	0	0
Hydroida	10	0	0
Askham's Gift	50	0	0
Nitrite of Amyle	10	0	0
Nomenclature Committee	5	0	0
Rain-gauges	19	15	8
Cast-iron Investigation	20	0	0
Tidal Observations in the Humber	50	0	0
Spectral Rays	45	0	0
Luminous Meteors	20	0	0
	£1289	15	8

1865.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Balloon Committee	100	0	0
Hydroida	13	0	0
Rain-gauges	*30	0	0
Tidal Observations in the Humber	6	8	0
Hexylic Compounds	20	0	0
Amyl Compounds	20	0	0
Irish Flora	25	0	0
American Mollusca	3	9	0
Organic Acids	20	0	0
Lingula Flags Excavation	10	0	0
Eurypterus	50	0	0
Electrical Standards	100	0	0
Malta Caves Researches	30	0	0
Oyster Breeding	25	0	0
Gibraltar Caves Researches	150	0	0
Kent's Hole Excavations	100	0	0
Moon's Surface Observations	35	0	0
Marine Fauna	25	0	0
Dredging Aberdeenshire	25	0	0
Dredging Channel Islands	50	0	0
Zoological Nomenclature	5	0	0
Resistance of Floating Bodies in Water	100	0	0
Bath Waters Analysis	8	10	10
Luminous Meteors	40	0	0
	£1591	7	10

1866.

	£	s.	d.
Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	64	13	4
Balloon Committee	50	0	0
Metrical Committee...	50	0	0
British Rainfall	50	0	0
Kilkenny Coal Fields	16	0	0
Alum Bay Fossil Leaf-bed ...	15	0	0
Luminous Meteors	50	0	0
Lingula Flags Excavation ...	20	0	0
Chemical Constitution of Cast Iron	50	0	0
Amyl Compounds	25	0	0
Electrical Standards............	100	0	0
Malta Caves Exploration......	30	0	0
Kent's Hole Exploration	200	0	0
Marine Fauna, &c., Devon and Cornwall	25	0	0
Dredging Aberdeenshire Coast	25	0	0
Dredging Hebrides Coast ...	50	0	0
Dredging the Mersey	5	0	0
Resistance of Floating Bodies in Water	50	0	0
Polycyanides of Organic Radicals	29	0	0
Rigor Mortis	10	0	0
Irish Annelida	15	0	0
Catalogue of Crania	50	0	0
Didine Birds of Mascarene Islands	50	0	0
Typical Crania Researches ...	30	0	0
Palestine Exploration Fund...	100	0	0
	£1750	13	4

1867.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Meteorological Instruments, Palestine........................	50	0	0
Lunar Committee	120	0	0
Metrical Committee............	30	0	0
Kent's Hole Explorations ...	100	0	0
Palestine Explorations.........	50	0	0
Insect Fauna, Palestine	30	0	0
British Rainfall..................	50	0	0
Kilkenny Coal Fields	25	0	0
Alum Bay Fossil Leaf-bed ...	25	0	0
Luminous Meteors	50	0	0
Bournemouth, &c., Leaf-beds	30	0	0
Dredging Shetland	75	0	0
Steamship Reports Condensation	100	0	0
Electrical Standards............	100	0	0
Ethyl and Methyl Series	25	0	0
Fossil Crustacea..................	25	0	0
Sound under Water	24	4	0
North Greenland Fauna	75	0	0
North Greenland Plant Beds.	100	0	0
Iron and Steel Manufacture...	25	0	0
Patent Laws	30	0	0
	£1739	4	0

1868.

	£	s.	d.
Maintaining the Establishment at Kew Observatory...	600	0	0
Lunar Committee	120	0	0
Metrical Committee	50	0	0
Zoological Record...............	100	0	0
Kent's Hole Explorations	150	0	0
Steamship Performances	100	0	0
British Rainfall..................	50	0	0
Luminous Meteors	50	0	0
Organic Acids	60	0	0
Fossil Crustacea	25	0	0
Methyl Series	25	0	0
Mercury and Bile	25	0	0
Organic Remains in Limestone Rocks.....................	25	0	0
Scottish Earthquakes	20	0	0
Fauna, Devon and Cornwall ..	30	0	0
British Fossil Carols............	50	0	0
Bagshot Leaf-beds	50	0	0
Greenland Explorations	100	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature ...	50	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Secondary Reptiles, &c.	30	0	0
British Marine Invertebrate Fauna	100	0	0
	£1940	0	0

1869.

Maintaining the Establishment at Kew Observatory..	600	0	0
Lunar Committee	50	0	0
Metrical Committee............	25	0	0
Zoological Record...............	100	0	0
Committee on Gases in Deep-well Water.....................	25	0	0
British Rainfall..................	50	0	0
Thermal Conductivity of Iron, &c.	30	0	0
Kent's Hole Explorations......	150	0	0
Steamship Performances......	30	0	0
Chemical Constitution of Cast Iron.......................	80	0	0
Iron and Steel Manufacture...	100	0	0
Methyl Series....................	30	0	0
Organic Remains in Limestone Rocks	10	0	0
Earthquakes in Scotland	10	0	0
British Fossil Corals............	50	0	0
Bagshot Leaf-beds	30	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature ...	30	0	0
Spectroscopic Investigations of Animal Substances	5	0	0
Organic Acids....................	12	0	0
Kiltorcan Fossils	20	0	0

	£	s.	d.
Chemical Constitution and Physiological Action Relations	15	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	10	0	0
Products of Digestion	10	0	0
	£1622	0	0

1870.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Committee on Marine Fauna	20	0	0
Ears in Fishes	10	0	0
Chemical Nature of Cast Iron	80	0	0
Luminous Meteors	30	0	0
Heat in the Blood	15	0	0
British Rainfall	100	0	0
Thermal Conductivity of Iron, &c.	20	0	0
British Fossil Corals	50	0	0
Kent's Hole Explorations	150	0	0
Scottish Earthquakes	4	0	0
Bagshot Leaf-beds	15	0	0
Fossil Flora	25	0	0
Tidal Observations	100	0	0
Underground Temperature	50	0	0
Kiltorcan Quarries Fossils	20	0	0
Mountain Limestone Fossils	25	0	0
Utilisation of Sewage	50	0	0
Organic Chemical Compounds	30	0	0
Onny River Sediment	3	0	0
Mechanical Equivalent of Heat	50	0	0
	£1572	0	0

1871.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	600	0	0
Monthly Reports of Progress in Chemistry	100	0	0
Metrical Committee	25	0	0
Zoological Record	100	0	0
Thermal Equivalents of the Oxides of Chlorine	10	0	0
Tidal Observation	100	0	0
Fossil Flora	25	0	0
Luminous Meteors	30	0	0
British Fossil Corals	25	0	0
Heat in the Blood	7	2	6
British Rainfall	50	0	0
Kent's Hole Explorations	150	0	0
Fossil Crustacea	25	0	0
Methyl Compounds	25	0	0
Lunar Objects	20	0	0
Fossil Coral Sections, for Photographing	20	0	0
Bagshot Leaf-beds	20	0	0
Moab Explorations	100	0	0
Gaussian Constants	40	0	0
	£1472	2	6

1872.

	£	s.	d.
Maintaining the Establishment at Kew Observatory	300	0	0
Metrical Committee	75	0	0
Zoological Record	100	0	0
Tidal Committee	200	0	0
Carboniferous Corals	25	0	0
Organic Chemical Compounds	25	0	0
Exploration of Moab	100	0	0
Terato-embryological Inquiries	10	0	0
Kent's Cavern Exploration	100	0	0
Luminous Meteors	20	0	0
Heat in the Blood	15	0	0
Fossil Crustacea	25	0	0
Fossil Elephants of Malta	25	0	0
Lunar Objects	20	0	0
Inverse Wave-lengths	20	0	0
British Rainfall	100	0	0
Poisonous Substances Antagonism	10	0	0
Essential Oils, Chemical Constitution, &c.	40	0	0
Mathematical Tables	50	0	0
Thermal Conductivity of Metals	25	0	0
	£1285	0	0

1873.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	200	0	0
Tidal Committee	400	0	0
Sewage Committee	100	0	0
Kent's Cavern Exploration	150	0	0
Carboniferous Corals	25	0	0
Fossil Elephants	25	0	0
Wave-lengths	150	0	0
British Rainfall	100	0	0
Essential Oils	30	0	0
Mathematical Tables	100	0	0
Gaussian Constants	10	0	0
Sub-Wealden Explorations	25	0	0
Underground Temperature	150	0	0
Settle Cave Exploration	50	0	0
Fossil Flora, Ireland	20	0	0
Timber Denudation and Rainfall	20	0	0
Luminous Meteors	30	0	0
	£1685	0	0

1874.

	£	s.	d.
Zoological Record	100	0	0
Chemistry Record	100	0	0
Mathematical Tables	100	0	0
Elliptic Functions	100	0	0
Lightning Conductors	10	0	0
Thermal Conductivity of Rocks	10	0	0
Anthropological Instructions	50	0	0
Kent's Cavern Exploration	150	0	0
Luminous Meteors	30	0	0
Intestinal Secretions	15	0	0
British Rainfall	100	0	0
Essential Oils	10	0	0
Sub-Wealden Explorations	25	0	0
Settle Cave Exploration	50	0	0
Mauritius Meteorology	100	0	0
Magnetisation of Iron	20	0	0
Marine Organisms	30	0	0
Fossils, North-West of Scotland	2	10	0
Physiological Action of Light	20	0	0
Trades Unions	25	0	0
Mountain Limestone Corals	25	0	0
Erratic Blocks	10	0	0
Dredging, Durham and Yorkshire Coasts	28	5	0
High Temperature of Bodies	30	0	0
Siemens's Pyrometer	3	6	0
Labyrinthodonts of Coal-measures	7	15	0
	£1151	16	0

1875.

	£	s.	d.
Elliptic Functions	100	0	0
Magnetisation of Iron	20	0	0
British Rainfall	120	0	0
Luminous Meteors	30	0	0
Chemistry Record	100	0	0
Specific Volume of Liquids	25	0	0
Estimation of Potash and Phosphoric Acid	10	0	0
Isometric Cresols	20	0	0
Sub-Wealden Explorations	100	0	0
Kent's Cavern Exploration	100	0	0
Settle Cave Exploration	50	0	0
Earthquakes in Scotland	15	0	0
Underground Waters	10	0	0
Development of Myxinoid Fishes	20	0	0
Zoological Record	100	0	0
Instructions for Travellers	20	0	0
Intestinal Secretions	20	0	0
Palestine Exploration	100	0	0
	£960	0	0

1876.

	£	s.	d.
Printing Mathematical Tables	159	4	2
British Rainfall	100	0	0
Ohm's Law	9	15	0
Tide Calculating Machine	200	0	0
Specific Volume of Liquids	25	0	0
Isomeric Cresols	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	5	0	0
Estimation of Potash and Phosphoric Acid	13	0	0
Exploration of Victoria Cave	100	0	0
Geological Record	100	0	0
Kent's Cavern Exploration	100	0	0
Thermal Conductivities of Rocks	10	0	0
Underground Waters	10	0	0
Earthquakes in Scotland	1	10	0
Zoological Record	100	0	0
Close Time	5	0	0
Physiological Action of Sound	25	0	0
Naples Zoological Station	75	0	0
Intestinal Secretions	15	0	0
Physical Characters of Inhabitants of British Isles	13	15	0
Measuring Speed of Ships	10	0	0
Effect of Propeller on turning of Steam-vessels	5	0	0
	£1092	4	2

1877.

	£	s.	d.
Liquid Carbonic Acid in Minerals	20	0	0
Elliptic Functions	250	0	0
Thermal Conductivity of Rocks	9	11	7
Zoological Record	100	0	0
Kent's Cavern	100	0	0
Zoological Station at Naples	75	0	0
Luminous Meteors	30	0	0
Elasticity of Wires	100	0	0
Dipterocarpeæ, Report on	20	0	0
Mechanical Equivalent of Heat	35	0	0
Double Compounds of Cobalt and Nickel	8	0	0
Underground Temperature	50	0	0
Settle Cave Exploration	100	0	0
Underground Waters in New Red Sandstone	10	0	0
Action of Ethyl Bromobutyrate on Ethyl Sodaceto-acetate	10	0	0
British Earthworks	25	0	0
Atmospheric Electricity in India	15	0	0
Development of Light from Coal-gas	20	0	0
Estimation of Potash and Phosphoric Acid	1	18	0
Geological Record	100	0	0
Anthropometric Committee	34	0	0
Physiological Action of Phosphoric Acid, &c.	15	0	0
	£1128	9	7

1878.

	£	s.	d.
Exploration of Settle Caves...	100	0	0
Geological Record...............	100	0	0
Investigation of Pulse Phenomena by means of Siphon Recorder........................	10	0	0
Zoological Station at Naples	75	0	0
Investigation of Underground Waters...........................	15	0	0
Transmission of Electrical Impulses through Nerve Structure..................	30	0	0
Calculation of Factor Table for Fourth Million	100	0	0
Anthropometric Committee...	66	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Kent's Cavern	50	0	0
Zoological Record...............	100	0	0
Fermanagh Caves Exploration	15	0	0
Thermal Conductivity of Rocks	4	16	6
Luminous Meteors...............	10	0	0
Ancient Earthworks	25	0	0
	£725	16	6

1879.

	£	s.	d.
Table at the Zoological Station, Naples	75	0	0
Miocene Flora of the Basalt of the North of Ireland ...	20	0	0
Illustrations for a Monograph on the Mammoth	17	0	0
Record of Zoological Literature	100	0	0
Composition and Structure of less-known Alkaloids	25	0	0
Exploration of Caves in Borneo	50	0	0
Kent's Cavern Exploration ...	100	0	0
Record of the Progress of Geology	100	0	0
Fermanagh Caves Exploration	5	0	0
Electrolysis of Metallic Solutions and Solutions of Compound Salts..............	25	0	0
Anthropometric Committee...	50	0	0
Natural History of Socotra ...	100	0	0
Calculation of Factor Tables for 5th and 6th Millions ...	150	0	0
Underground Waters............	10	0	0
Steering of Screw Steamers...	10	0	0
Improvements in Astronomical Clocks	30	0	0
Marine Zoology of South Devon	20	0	0
Determination of Mechanical Equivalent of Heat	12	15	6
Specific Inductive Capacity of Sprengel Vacuum.........	40	0	0
Tables of Sun-heat Coefficients	30	0	0
Datum Level of the Ordnance Survey	10	0	0
Tables of Fundamental Invariants of Algebraic Forms	36	14	9
Atmospheric Electricity Observations in Madeira	15	0	0
Instrument for Detecting Fire-damp in Mines	22	0	0
Instruments for Measuring the Speed of Ships	17	1	8
Tidal Observations in the English Channel	10	0	0
	£1080	11	11

1880.

	£	s.	d.
New Form of High Insulation Key	10	0	0
Underground Temperature ...	10	0	0
Determination of the Mechanical Equivalent of Heat	8	5	0
Elasticity of Wires	50	0	0
Luminous Meteors	30	0	0
Lunar Disturbance of Gravity	30	0	0
Fundamental Invariants	8	5	0
Laws of Water Friction	20	0	0
Specific Inductive Capacity of Sprengel Vacuum.........	20	0	0
Completion of Tables of Sun-heat Coefficients	50	0	0
Instrument for Detection of Fire-damp in Mines	10	0	0
Inductive Capacity of Crystals and Paraffines	4	17	7
Report on Carboniferous Polyzoa	10	0	0
Caves of South Ireland	10	0	0
Viviparous Nature of Ichthyosaurus	10	0	0
Kent's Cavern Exploration...	50	0	0
Geological Record..............	100	0	0
Miocene Flora of the Basalt of North Ireland	15	0	0
Underground Waters of Permian Formations	5	0	0
Record of Zoological Literature	100	0	0
Table at Zoological Station at Naples	75	0	0
Investigation of the Geology and Zoology of Mexico......	50	0	0
Anthropometry	50	0	0
Patent Laws	5	0	0
	£731	7	7

1881.

	£	s.	d.
Lunar Disturbance of Gravity	30	0	0
Underground Temperature ...	20	0	0
Electrical Standards........ ...	25	0	0
High Insulation Key...........	5	0	0
Tidal Observations	10	0	0
Specific Refractions	7	3	1
Fossil Polyzoa	10	0	0
Underground Waters	10	0	0
Earthquakes in Japan	25	0	0
Tertiary Flora	20	0	0
Scottish Zoological Station ...	50	0	0
Naples Zoological Station ...	75	0	0
Natural History of Socotra ...	50	0	0
Anthropological Notes and Queries	9	0	0
Zoological Record..............	100	0	0
Weights and Heights of Human Beings	30	0	0
	£476	3	1

1882.

	£	s.	d.
Exploration of Central Africa	100	0	0
Fundamental Invariants of Algebraical Forms	76	1	11
Standards for Electrical Measurements	100	0	0
Calibration of Mercurial Thermometers	20	0	0
Wave-length Tables of Spectra of Elements..............	50	0	0
Photographing Ultra-violet Spark Spectra	25	0	0
Geological Record..............	100	0	0
Earthquake Phenomena of Japan	25	0	0
Conversion of Sedimentary Materials into Metamorphic Rocks	10	0	0
Fossil Plants of Halifax	15	0	0
Geological Map of Europe ...	25	0	0
Circulation of Underground Waters.........................	15	0	0
Tertiary Flora of North of Ireland	20	0	0
British Polyzoa	10	0	0
Exploration of Caves of South of Ireland	10	0	0
Exploration of Raygill Fissure	20	0	0
Naples Zoological Station ...	80	0	0
Albuminoid Substances of Serum	10	0	0
Elimination of Nitrogen by Bodily Exercise..............	50	0	0
Migration of Birds	15	0	0
Natural History of Socotra...	100	0	0
Natural History of Timor-laut	100	0	0
Record of Zoological Literature	100	0	0
Anthropometric Committee...	50	0	0
	£1126	1	11

1883.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Isomeric Naphthalene Derivatives................	15	0	0
Earthquake Phenomena of Japan	50	0	0
Fossil Plants of Halifax	20	0	0
British Fossil Polyzoa	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Erosion of Sea-coast of England and Wales	10	0	0
Circulation of Underground Waters.........................	15	0	0
Geological Record..............	50	0	0
Exploration of Caves in South of Ireland	10	0	0
Zoological Literature Record	100	0	0
Migration of Birds	20	0	0
Zoological Station at Naples	80	0	0
Scottish Zoological Station...	25	0	0
Elimination of Nitrogen by Bodily Exercise..............	38	3	3
Exploration of Mount Kilima-njaro.......................	500	0	0
Investigation of Loughton Camp	10	0	0
Natural History of Timor-laut	50	0	0
Screw Gauges.....................	5	0	0
	£1083	3	3

1884.

	£	s.	d.
Meteorological Observations on Ben Nevis	50	0	0
Collecting and Investigating Meteoric Dust.................	20	0	0
Meteorological Observatory at Chepstow.......................	25	0	0
Tidal Observations..............	10	0	0
Ultra Violet Spark Spectra ...	8	4	0
Earthquake Phenomena of Japan	75	0	0
Fossil Plants of Halifax	15	0	0
Fossil Polyzoa....................	10	0	0
Erratic Blocks of England ...	10	0	0
Fossil Phyllopoda of Palæozoic Rocks	15	0	0
Circulation of Underground Waters.........................	5	0	0
International Geological Map	20	0	0
Bibliography of Groups of Invertebrata	50	0	0
Natural History of Timor-laut	50	0	0
Naples Zoological Station ...	80	0	0
Exploration of Mount Kilima-njaro, East Africa	500	0	0
Migration of Birds..............	20	0	0
Coagulation of Blood...........	100	0	0
Zoological Literature Record	100	0	0
Anthropometric Committee...	10	0	0
	£1173	4	0

1885.

	£	s.	d.
Synoptic Chart of Indian Ocean	50	0	0
Reduction of Tidal Observations	10	0	0
Calculating Tables in Theory of Numbers	100	0	0
Meteorological Observations on Ben Nevis	50	0	0
Meteoric Dust	70	0	0
Vapour Pressures, &c., of Salt Solutions	25	0	0
Physical Constants of Solutions	20	0	0
Volcanic Phenomena of Vesuvius	25	0	0
Raygill Fissure	15	0	0
Earthquake Phenomena of Japan	70	0	0
Fossil Phyllopoda of Palæozoic Rocks	25	0	0
Fossil Plants of British Tertiary and Secondary Beds...	50	0	0
Geological Record	50	0	0
Circulation of Underground Waters	10	0	0
Naples Zoological Station ...	100	0	0
Zoological Literature Record.	100	0	0
Migration of Birds	30	0	0
Exploration of Mount Kilimanjaro	25	0	0
Recent Polyzoa	10	0	0
Granton Biological Station ...	100	0	0
Biological Stations on Coasts of United Kingdom	150	0	0
Exploration of New Guinea ..	200	0	0
Exploration of Mount Roraima	100	0	0
	£1385	0	0

1886.

	£	s.	d.
Electrical Standards	40	0	0
Solar Radiation	9	10	6
Tidal Observations	50	0	0
Magnetic Observations	10	10	0
Observations on Ben Nevis ...	100	0	0
Physical and Chemical Bearings of Electrolysis	20	0	0
Chemical Nomenclature	5	0	0
Fossil Plants of British Tertiary and Secondary Beds...	20	0	0
Caves in North Wales	25	0	0
Volcanic Phenomena of Vesuvius	30	0	0
Geological Record	100	0	0
Palæozoic Phyllopoda	15	0	0
Zoological Literature Record.	100	0	0
Granton Biological Station ...	75	0	0
Naples Zoological Station	50	0	0
Researches in Food-Fishes and Invertebrata at St. Andrews	75	0	0
Migration of Birds	30	0	0
Secretion of Urine	10	0	0
Exploration of New Guinea...	150	0	0
Regulation of Wages under Sliding Scales	10	0	0
Prehistoric Race in Greek Islands	20	0	0
North-Western Tribes of Canada	50	0	0
	£995	0	6

1887.

	£	s.	d.
Solar Radiation	18	10	0
Electrolysis	30	0	0
Ben Nevis Observatory	75	0	0
Standards of Light (1886 grant)	20	0	0
Standards of Light (1887 grant)	10	0	0
Harmonic Analysis of Tidal Observations	15	0	0
Magnetic Observations	26	2	0
Electrical Standards	50	0	0
Silent Discharge of Electricity	20	0	0
Absorption Spectra	40	0	0
Nature of Solution	20	0	0
Influence of Silicon on Steel	30	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Volcanic Phenomena of Japan (1886 grant)	50	0	0
Volcanic Phenomena of Japan (1887 grant)	50	0	0
Cae Gwyn Cave, N. Wales ...	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	20	0	0
Coal Plants of Halifax	25	0	0
Microscopic Structure of the Rocks of Anglesey	10	0	0
Exploration of the Eocene Beds of the Isle of Wight...	20	0	0
Underground Waters	5	0	0
'Manure' Gravels of Wexford	10	0	0
Provincial Museums Reports	5	0	0
Lymphatic System	25	0	0
Naples Biological Station ...	100	0	0
Plymouth Biological Station	50	0	0
Granton Biological Station ...	75	0	0
Zoological Record	100	0	0
Flora of China	75	0	0
Flora and Fauna of the Cameroons	75	0	0
Migration of Birds	30	0	0
Bathy-hypsographical Map of British Isles	7	6	0
Regulation of Wages	10	0	0
Prehistoric Race of Greek Islands	20	0	0
Racial Photographs, Egyptian	20	0	0
	£1186	18	0

1888.

	£	s.	d.
Ben Nevis Observatory	150	0	0
Electrical Standards	2	6	4
Magnetic Observations	15	0	0
Standards of Light	79	2	3
Electrolysis	30	0	0
Uniform Nomenclature in Mechanics	10	0	0
Silent Discharge of Electricity	9	11	10
Properties of Solutions	25	0	0
Influence of Silicon on Steel	20	0	0
Methods of teaching Chemistry	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Action of Light on Hydracids	20	0	0
Sea Beach near Bridlington	20	0	0
Geological Record	50	0	0
Manure Gravels of Wexford	10	0	0
Erosion of Sea Coasts	10	0	0
Underground Waters	5	0	0
Palæontographical Society	50	0	0
Pliocene Fauna of St. Erth	50	0	0
Carboniferous Flora of Lancashire and West Yorkshire	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Zoology and Botany of West Indies	100	0	0
Flora of Bahamas	100	0	0
Development of Fishes—St. Andrews	50	0	0
Marine Laboratory, Plymouth	100	0	0
Migration of Birds	30	0	0
Flora of China	75	0	0
Naples Zoological Station	100	0	0
Lymphatic System	25	0	0
Biological Station at Granton	50	0	0
Peradeniya Botanical Station	50	0	0
Development of Teleostei	15	0	0
Depth of Frozen Soil in Polar Regions	5	0	0
Precious Metals in Circulation	20	0	0
Value of Monetary Standard	10	0	0
Effect of Occupations on Physical Development	25	0	0
North-Western Tribes of Canada	100	0	0
Prehistoric Race in Greek Islands	20	0	0
	£1511	0	5

1889.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	75	0	0
Electrolysis	20	0	0
Surface Water Temperature	30	0	0
Silent Discharge of Electricity on Oxygen	6	4	8
Methods of teaching Chemistry	10	0	0
Action of Light on Hydracids	10	0	0
Geological Record	80	0	0
Volcanic Phenomena of Japan	25	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	20	0	0
Higher Eocene Beds of Isle of Wight	15	0	0
West Indian Explorations	100	0	0
Flora of China	25	0	0
Naples Zoological Station	100	0	0
Physiology of Lymphatic System	25	0	0
Experiments with a Tow-net	5	16	3
Natural History of Friendly Islands	100	0	0
Geology and Geography of Atlas Range	100	0	0
Action of Waves and Currents in Estuaries	100	0	0
North-Western Tribes of Canada	150	0	0
Nomad Tribes of Asia Minor	30	0	0
Corresponding Societies	20	0	0
Marine Biological Association	200	0	0
'Baths Committee,' Bath	100	0	0
	£1117	0	11

1890.

	£	s.	d.
Electrical Standards	12	17	0
Electrolysis	5	0	0
Electro-optics	50	0	0
Mathematical Tables	25	0	0
Volcanic and Seismological Phenomena of Japan	75	0	0
Pellian Equation Tables	15	0	0
Properties of Solutions	10	0	0
International Standard for the Analysis of Iron and Steel	10	0	0
Influence of the Silent Discharge of Electricity on Oxygen	5	0	0
Methods of teaching Chemistry	10	0	0
Recording Results of Water Analysis	4	1	0
Oxidation of Hydracids in Sunlight	15	0	0
Volcanic Phenomena of Vesuvius	20	0	0
Palæozoic Phyllopoda	10	0	0
Circulation of Underground Waters	5	0	0
Excavations at Oldbury Hill	15	0	0
Cretaceous Polyzoa	10	0	0
Geological Photographs	7	14	11
Lias Beds of Northampton	25	0	0
Botanical Station at Peradeniya	25	0	0

	£	s.	d.
Experiments with a Tow-net	4	3	9
Naples Zoological Station	100	0	0
Zoology and Botany of the West India Islands	100	0	0
Marine Biological Association	30	0	0
Action of Waves and Currents in Estuaries	150	0	0
Graphic Methods in Mechanical Science	11	0	0
Anthropometric Calculations	5	0	0
Nomad Tribes of Asia Minor	25	0	0
Corresponding Societies	20	0	0
	£799	16	8

1891.

	£	s.	d.
Ben Nevis Observatory	50	0	0
Electrical Standards	100	0	0
Electrolysis	5	0	0
Seismological Phenomena of Japan	10	0	0
Temperatures of Lakes	20	0	0
Photographs of Meteorological Phenomena	5	0	0
Discharge of Electricity from Points	10	0	0
Ultra Violet Rays of Solar Spectrum	50	0	0
International Standard for Analysis of Iron and Steel	10	0	0
Isomeric Naphthalene Derivatives	25	0	0
Formation of Haloids	25	0	0
Action of Light on Dyes	17	10	0
Geological Record	100	0	0
Volcanic Phenomena of Vesuvius	10	0	0
Fossil Phyllopoda	10	0	0
Photographs of Geological Interest	9	5	0
Lias of Northamptonshire	25	0	0
Registration of Type-Specimens of British Fossils	5	5	0
Investigation of Elbolton Cave	25	0	0
Botanical Station at Peradeniya	50	0	0
Experiments with a Tow-net	40	0	0
Marine Biological Association	12	10	0
Disappearance of Native Plants	5	0	0
Action of Waves and Currents in Estuaries	125	0	0
Anthropometric Calculations	10	0	0
New Edition of 'Anthropological Notes and Queries'	50	0	0
North - Western Tribes of Canada	200	0	0
Corresponding Societies	25	0	0
	£1029	10	0

1892.

	£	s.	d.
Observations on Ben Nevis	50	0	0
Photographs of Meteorological Phenomena	15	0	0
Pellian Equation Tables	10	0	0
Discharge of Electricity from Points	50	0	0
Seismological Phenomena of Japan	10	0	0
Formation of Haloids	12	0	0
Properties of Solutions	10	0	0
Action of Light on Dyed Colours	10	0	0
Erratic Blocks	15	0	0
Photographs of Geological Interest	20	0	0
Underground Waters	10	0	0
Investigation of Elbolton Cave	25	0	0
Excavations at Oldbury Hill	10	0	0
Cretaceous Polyzoa	10	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	17	10	0
Deep-sea Tow-net	40	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	100	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Anthropometric Laboratory	5	0	0
Anthropological Notes and Queries	20	0	0
Prehistoric Remains in Mashonaland	50	0	0
North - Western Tribes of Canada	100	0	0
Corresponding Societies	25	0	0
	£864	10	0

1893.

	£	s.	d.
Electrical Standards	25	0	0
Observations on Ben Nevis	150	0	0
Mathematical Tables	15	0	0
Intensity of Solar Radiation	2	8	6
Magnetic Work at the Falmouth Observatory	25	0	0
Isomeric Naphthalene Derivatives	20	0	0
Erratic Blocks	10	0	0
Fossil Phyllopoda	5	0	0
Underground Waters	5	0	0
Shell-bearing Deposits at Clava, Chapelhall, &c.	20	0	0
Eurypterids of the Pentland Hills	10	0	0
Naples Zoological Station	100	0	0
Marine Biological Association	30	0	0
Fauna of Sandwich Islands	100	0	0
Zoology and Botany of West India Islands	50	0	0

	£	s.	d.
Exploration of Irish Sea	30	0	0
Physiological Action of Oxygen in Asphyxia	20	0	0
Index of Genera and Species of Animals	20	0	0
Exploration of Karakoram Mountains	50	0	0
Scottish Place-names	7	0	0
Climatology and Hydrography of Tropical Africa	50	0	0
Economic Training	3	7	0
Anthropometric Laboratory...	5	0	0
Exploration in Abyssinia......	25	0	0
North-Western Tribes of Canada	100	0	0
Corresponding Societies	30	0	0
	£907	15	6

1894.

	£	s.	d.
Electrical Standards............	25	0	0
Photographs of Meteorological Phenomena...............	10	0	0
Tables of Mathematical Functions	15	0	0
Intensity of Solar Radiation	5	5	6
Wave-length Tables	10	0	0
Action of Light upon Dyed Colours	5	0	0
Erratic Blocks	15	0	0
Fossil Phyllopoda	5	0	0
Shell-bearing Deposits at Clava, &c.	20	0	0
Eurypterids of the Pentland Hills..........................	5	0	0
New Sections of Stonesfield Slate	14	0	0
Observations on Earth Tremors	50	0	0
Exploration of Calf-Hole Cave.....	5	0	0
Naples Zoological Station ...	100	0	0
Marine Biological Association	5	0	0
Zoology of the Sandwich Islands	100	0	0
Zoology of the Irish Sea	40	0	0
Structure and Function of the Mammalian Heart...........	10	0	0
Exploration in Abyssinia ...	30	0	0
Economic Training	9	10	0
Anthropometric Laboratory Statistics......................	5	0	0
Ethnographical Survey	10	0	0
The Lake Village at Glastonbury............................	40	0	0
Anthropometrical Measurements in Schools	5	0	0
Mental and Physical Condition of Children..............	20	0	0
Corresponding Societies	25	0	0
	£583	15	6

1895.

	£	s.	d.
Electrical Standards............	5	0	0
Photographs of Meteorological Phenomena......................	10	0	0
Earth Tremors	75	0	0
Abstracts of Physical Papers	100	0	0
Reduction of Magnetic Observations made at Falmouth Observatory	50	0	0
Comparison of Magnetic Standards	25	0	0
Meteorological Observations on Ben Nevis	50	0	0
Wave-length Tables of the Spectra of the Elements ...	10	0	0
Action of Light upon Dyed Colours	4	6	1
Formation of Haloids from Pure Materials	20	0	0
Isomeric Naphthalene Derivatives..........................	30	0	0
Electrolytic Quantitative Analysis	30	0	0
Erratic Blocks	10	0	0
Palæozoic Phyllopoda	5	0	0
Photographs of Geological Interest	10	0	0
Shell-bearing Deposits at Clava, &c.	10	0	0
Eurypterids of the Pentland Hills.....	3	0	0
New Sections of Stonesfield Slate	50	0	0
Exploration of Calf Hole Cave	10	0	0
Nature and Probable Age of High-level Flint-drifts	10	0	0
Table at the Zoological Station at Naples	100	0	0
Table at the Biological Laboratory, Plymouth	15	0	0
Zoology, Botany, and Geology of the Irish Sea..............	35	9	4
Zoology and Botany of the West India Islands	50	0	0
Index of Genera and Species of Animals	50	0	0
Climatology of Tropical Africa	5	0	0
Exploration of Hadramut ...	50	0	0
Calibration and Comparison of Measuring Instruments ...	25	0	0
Anthropometric Measurements in Schools	5	0	0
Lake Village at Glastonbury	30	0	0
Exploration of a Kitchen-midden at Hastings	10	0	0
Ethnographical Survey	10	0	0
Physiological Applications of the Phonograph...............	25	0	0
Corresponding Societies	30	0	0
	£977	15	5

	£	s.	d.
Isomorphous Sulphonic Derivatives of Benzone	20	0	0
The Nature of Alloys	30	0	0
Photographs of Geological Interest	10	0	0
Remains of Elk in the Isle of Man	5	0	0
Pleistocene Fauna and Flora in Canada	10	0	0
Movements of Underground Waters of Craven	40	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	50	0	0
Migration of Birds	15	0	0
Plankton and Physical Conditions of the English Channel	40	0	0
Zoology of the Sandwich Islands	100	0	0
Coral Reefs of the Indian Region	30	0	0
Physical and Chemical Constants of Sea-Water	100	0	0
Future Dealings in Raw Produce	2	10	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	50	0	0
New Edition of 'Anthropological Notes and Queries'	40	0	0
Photographs of Anthropological Interest	10	0	0
Mental and Physical Condition of Children in Schools	5	0	0
Ethnography of the Malay Peninsula	25	0	0
Physiological Effects of Peptone	20	0	0
Comparative Histology of Suprarenal Capsules	20	0	0
Comparative Histology of Cerebral Cortex	5	0	0
Electrical Changes in Mammalian Nerves	20	0	0
Vascular Supply of Secreting Glands	10	0	0
Fertilisation in Phæophyceæ	20	0	0
Corresponding Societies Committee	20	0	0
	£1072	10	0

1901.

	£	s.	d.
Electrical Standards	45	0	0
Seismological Observations	75	0	0
Wave-length Tables	4	14	0
Isomorphous Sulphonic Derivatives of Benzene	35	0	0
Life-zones in British Carboniferous Rocks	20	0	0
Underground Water of North-west Yorkshire	50	0	0
Exploration of Irish Caves	15	0	0
Table at the Zoological Station, Naples	100	0	0
Table at the Biological Laboratory, Plymouth	20	0	0
Index Generum et Specierum Animalium	75	0	0
Migration of Birds	10	0	0
Terrestrial Surface Waves	5	0	0
Changes of Land-level in the Phlegræan Fields	50	0	0
Legislation regulating Women's Labour	15	0	0
Small Screw Gauge	45	0	0
Resistance of Road Vehicles to Traction	75	0	0
Silchester Excavation	10	0	0
Ethnological Survey of Canada	30	0	0
Anthropological Teaching	5	0	0
Exploration in Crete	145	0	0
Physiological Effects of Peptone	30	0	0
Chemistry of Bone Marrow	5	15	11
Suprarenal Capsules in the Rabbit	5	0	0
Fertilisation in Phæophyceæ	15	0	0
Morphology, Ecology, and Taxonomy of Podostemaceæ	20	0	0
Corresponding Societies Committee	15	0	0
	£920	9	11

1902.

	£	s.	d.
Electrical Standards	40	0	0
Seismological Observations	35	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	80	0	0
Relation between Absorption Spectra and Organic Substances	20	0	0
Wave-length Tables	5	0	0
Life-zones in British Carboniferous Rocks	10	0	0
Exploration of Irish Caves	45	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Migration of Birds	15	0	0
Structure of Coral Reefs of Indian Ocean	50	0	0

	£	s.	d.
Compound Ascidians of the Clyde Area	25	0	0
Terrestrial Surface Waves	15	0	0
Legislation regulating Women's Labour	30	0	0
Small Screw Gauge	20	0	0
Resistance of Road Vehicles to Traction	50	0	0
Ethnological Survey of Canada	15	0	0
Age of Stone Circles	30	0	0
Exploration in Crete	100	0	0
Anthropometric Investigation of Native Egyptian Soldiers	15	0	0
Excavations on the Roman Site at Gelligaer	5	0	0
Changes in Hæmoglobin	15	0	0
Work of Mammalian Heart under Influence of Drugs	20	0	0
Investigation of the Cyanophyceæ	10	0	0
Reciprocal Influence of Universities and Schools	5	0	0
Conditions of Health essential to carrying on Work in Schools	2	0	0
Corresponding Societies Committee	15	0	0
	£947	0	0

1903.

	£	s.	d.
Electrical Standards	35	0	0
Seismological Observations	40	0	0
Investigation of the Upper Atmosphere by means of Kites	75	0	0
Magnetic Observations at Falmouth	40	0	0
Study of Hydro-aromatic Substances	20	0	0
Erratic Blocks	10	0	0
Exploration of Irish Caves	40	0	0
Underground Waters of North-west Yorkshire	40	0	0
Life-zones in British Carboniferous Rocks	5	0	0
Geological Photographs	10	0	0
Table at the Zoological Station at Naples	100	0	0
Index Generum et Specierum Animalium	100	0	0
Tidal Bore, Sea Waves, and Beaches	15	0	0
Scottish National Antarctic Expedition	50	0	0
Legislation affecting Women's Labour	25	0	0
Researches in Crete	100	0	0
Age of Stone Circles	3	13	2
Anthropometric Investigation	5	0	0
Anthropometry of the Todas and other Tribes of Southern India	50	0	0
The State of Solution of Proteids	20	0	0
Investigation of the Cyanophyceæ	25	0	0
Respiration of Plants	12	0	0
Conditions of Health essential for School Instruction	5	0	0
Corresponding Societies Committee	20	0	0
	£845	13	2

1904.

	£	s.	d.
Seismological Observations	40	0	0
Investigation of the Upper Atmosphere by means of Kites	50	0	0
Magnetic Observations at Falmouth	60	0	0
Wave-length Tables of Spectra	10	0	0
Study of Hydro-aromatic Substances	25	0	0
Erratic Blocks	10	0	0
Life-zones in British Carboniferous Rocks	35	0	0
Fauna and Flora of the Trias	10	0	0
Investigation of Fossiliferous Drifts	50	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	60	0	0
Development in the Frog	15	0	0
Researches on the Higher Crustacea	15	0	0
British and Foreign Statistics of International Trade	25	0	0
Resistance of Road Vehicles to Traction	90	0	0
Researches in Crete	100	0	0
Researches in Glastonbury Lake Village	25	0	0
Anthropometric Investigation of Egyptian Troops	8	10	0
Excavations on Roman Sites in Britain	25	0	0
The State of Solution of Proteids	20	0	0
Metabolism of Individual Tissues	40	0	0
Botanical Photographs	4	8	11
Respiration of Plants	15	0	0
Experimental Studies in Heredity	35	0	0
Corresponding Societies Committee	20	0	0
	£887	8	11

1905.

	£	s.	d.
Electrical Standards	40	0	0
Seismological Observations	40	0	0
Investigation of the Upper Atmosphere by means of Kites	10	0	0
Magnetic Observations at Falmouth	60	0	0
Wave-length Tables of Spectra	5	0	0
Study of Hydro-aromatic Substances	25	0	0
Dynamic Isomerism	20	0	0
Aromatic Nitramines	25	0	0
Fauna and Flora of the British Trias	10	0	0
Table at the Zoological Station, Naples	100	0	0
Index Generum et Specierum Animalium	75	0	0
Development of the Frog	10	0	0
Investigations in the Indian Ocean	150	0	0
Trade Statistics	4	4	8
Researches in Crete	75	0	0
Anthropometric Investigations of Egyptian Troops	10	0	0
Excavations on Roman Sites in Britain	10	0	0
Anthropometric Investigations	10	0	0
Age of Stone Circles	30	0	0
The State of Solution of Proteids	20	0	0
Metabolism of Individual Tissues	30	0	0
Ductless Glands	40	0	0
Botanical Photographs	3	17	6
Physiology of Heredity	35	0	0
Structure of Fossil Plants	50	0	0
Corresponding Societies Committee	20	0	0
	£928	2	2

1906.

	£	s.	d.
Electrical Standards	25	0	0
Seismological Observations	40	0	0
Magnetic Observations at Falmouth	50	0	0
Magnetic Survey of South Africa	99	12	6
Wave-length Tables of Spectra	5	0	0
Study of Hydro-aromatic Substances	25	0	0
Aromatic Nitramines	10	0	0
Fauna and Flora of the British Trias	7	8	11
Crystalline Rocks of Anglesey	30	0	0
Table at the Zoological Station, Naples	100	0	0
Index Animalium	75	0	0
Development of the Frog	10	0	0
Higher Crustacea	15	0	0
Freshwater Fishes of South Africa	50	0	0
Rainfall and Lake and River Discharge	10	0	0
Excavations in Crete	100	0	0
Lake Village at Glastonbury	40	0	0
Excavations on Roman Sites in Britain	30	0	0
Anthropometric Investigations in the British Isles	30	0	0
State of Solution of Proteids	20	0	0
Metabolism of Individual Tissues	20	0	0
Effect of Climate upon Health and Disease	20	0	0
Research on South African Cycads	14	19	4
Peat Moss Deposits	25	0	0
Studies suitable for Elementary Schools	5	0	0
Corresponding Societies Committee	25	0	0
	£882	0	9

1907.

	£	s.	d.
Electrical Standards	50	0	0
Seismological Observations	40	0	
Magnetic Observations at Falmouth	40	0	
Magnetic Survey of South Africa	25	7	
Wave-length Tables of Spectra	10	0	0
Study of Hydro-aromatic Substances	30	0	0
Dynamic Isomerism	30	0	0
Life Zones in British Carboniferous Rocks	10	0	0
Erratic Blocks	10	0	0
Fauna and Flora of British Trias	10	0	0
Faunal Succession in the Carboniferous Limestone of South-West England	15	0	0
Correlation and Age of South African Strata, &c.	10	0	0
Table at the Zoological Station, Naples	100	0	0
Index Animalium	75	0	0
Development of the Sexual Cells	1	11	8
Oscillations of the Land Level in the Mediterranean Basin	50	0	0
Gold Coinage in Circulation in the United Kingdom	8	19	7
Anthropometric Investigations in the British Isles	10	0	0
Metabolism of Individual Tissues	45	0	0
The Ductless Glands	25	0	0
Effect of Climate upon Health and Disease	55	0	0

	£	s.	d.
Physiology of Heredity	30	0	0
Research on South African Cycads	35	0	0
Botanical Photographs	5	0	0
Structure of Fossil Plants	5	0	0
Marsh Vegetation	15	0	0
Corresponding Societies Committee	16	14	1
	£757	12	10

1908.

	£	s.	d.
Seismological Observations	40	0	0
Further Tabulation of Bessel Functions	15	0	0
Investigation of Upper Atmosphere by means of Kites	25	0	0
Meteorological Observations on Ben Nevis	25	0	0
Geodetic Arc in Africa	200	0	0
Wave-length Tables of Spectra	10	0	0
Study of Hydro-aromatic Substances	30	0	0
Dynamic Isomerism	40	0	0
Transformation of Aromatic Nitramines	30	0	0
Erratic Blocks	17	16	6
Fauna and Flora of British Trias	10	0	0
Faunal Succession in the Carboniferous Limestone in the British Isles	10	0	0
Pre-Devonian Rocks	10	0	0
Exact Significance of Local Terms	5	0	0
Composition of Charnwood Rocks	10	0	0
Table at the Zoological Station at Naples	100	0	0
Index Animalium	75	0	0
Hereditary Experiments	10	0	0
Fauna of Lakes of Central Tasmania	40	0	0
Investigations in the Indian Ocean	50	0	0
Exploration in Spitsbergen	30	0	0
Gold Coinage in Circulation in the United Kingdom	3	7	6
Electrical Standards	50	0	0
Glastonbury Lake Village	30	0	0
Excavations on Roman Sites in Britain	15	0	0
Age of Stone Circles	50	0	0
Anthropological Notes and Queries	40	0	0
Metabolism of Individual Tissues	40	0	0
The Ductless Glands	13	14	8
Effect of Climate upon Health and Disease	35	0	0
Body Metabolism in Cancer	30	0	0
Electrical Phenomena and Metabolism of *Arum Spadices*	10	0	0
Marsh Vegetation	15	0	0
Succession of Plant Remains	18	0	0
Corresponding Societies Committee	25	0	0
	£1157	18	8

1909

	£	s.	d.
Seismological Observations	60	0	0
Investigation of the Upper Atmosphere by means of Kites	10	0	0
Magnetic Observations at Falmouth	50	0	0
Establishing a Solar Observatory in Australia	50	0	0
Wave-length Tables of Spectra	9	16	0
Study of Hydro aromatic Substances	15	0	0
Dynamic Isomerism	35	0	0
Transformation of Aromatic Nitramines	10	0	0
Electroanalysis	30	0	0
Fauna and Flora of British Trias	8	0	0
Faunal Succession in the Carboniferous Limestone in the British Isles	8	0	0
Palæozoic Rocks of Wales and the West of England	9	0	0
Igneous and Associated Sedimentary Rocks of Glensaul	11	13	9
Investigations at Biskra	50	0	0
Table at the Zoological Station at Naples	100	0	0
Heredity Experiments	10	0	0
Feeding Habits of British Birds	5	0	0
Index Animalium	75	0	0
Investigations in the Indian Ocean	35	0	0
Gaseous Explosions	75	0	0
Excavations on Roman Sites in Britain	5	0	0
Age of Stone Circles	30	0	0
Researches in Crete	70	0	0
The Ductless Glands	35	0	0
Electrical Phenomena and Metabolism of *Arum Spadices*	10	0	0
Reflex Muscular Rhythm	10	0	0
Anæsthetics	25	0	0
Mental and Muscular Fatigue	27	0	0
Structure of Fossil Plants	5	0	0
Botanical Photographs	10	0	0
Experimental Study of Heredity	30	0	0
Symbiosis between Turbellarian Worms and Algæ	10	0	0
Survey of Clare Island	65	0	0
Curricula of Secondary Schools	5	0	0
Corresponding Societies Committee	21	0	0
	£1014	9	9

1910.	£	s.	d.
Measurement of Geodetic Arc in South Africa	100	0	0
Republication of Electrical Standards Reports	100	0	0
Seismological Observations	60	0	0
Magnetic Observations at Falmouth	25	0	0
Investigation of the Upper Atmosphere	25	0	0
Study of Hydro-aromatic Substances	25	0	0
Dynamic Isomerism	35	0	0
Transformation of Aromatic Nitro-amines	15	0	0
Electroanalysis	10	0	0
Faunal Succession in the Carboniferous Limestone in the British Isles	10	0	0
South African Strata	5	0	0
Fossils of Midland Coalfields	25	0	0
Table at the Zoological Station at Naples	100	0	0
Index Animalium	75	0	0
Heredity Experiments	15	0	0
Feeding Habits of British Birds	5	0	0
Amount and Distribution of Income	15	0	0
Gaseous Explosions	75	0	0
Lake Villages in the neighbourhood of Glastonbury	5	0	0
Excavations on Roman Sites in Britain	5	0	0
Neolithic Sites in Northern Greece	5	0	0
The Ductless Glands	40	0	0
Body Metabolism in Cancer	20	0	0
Anæsthetics	25	0	0
Tissue Metabolism	25	0	0
Mental and Muscular Fatigue	18	17	0
Electromotive Phenomena in Plants	10	0	0
Structure of Fossil Plants	10	0	0
Experimental Study of Heredity	30	0	0
Survey of Clare Island	30	0	0
Corresponding Societies Committee	20	0	0
	£963	17	0

1911.	£	s.	d.
Seismological Investigations	60	0	0
Magnetic Observations at Falmouth	25	0	0
Investigation of the Upper Atmosphere	25	0	0
Grant to International Commission on Physical and Chemical Constants	30	0	0
Study of Hydro-aromatic Substances	20	0	0
Dynamic Isomerism	25	0	0
Transformation of Aromatic Nitro-amines	15	0	0
Electroanalysis	15	0	0
Influence of Carbon, &c., on Corrosion of Steel	15	0	0
Crystalline Rocks of Anglesey	2	0	0
Mammalian Fauna in Miocene Deposits, Bugti Hills, Baluchistan	75	0	0
Table at the Zoological Station at Naples	100	0	0
Index Animalium	75	0	0
Feeding Habits of British Birds	5	0	0
Belmullet Whaling Station	30	0	0
Map of Prince Charles Foreland	30	0	0
Gaseous Explosions	90	0	0
Lake Villages in the neighbourhood of Glastonbury	5	0	0
Age of Stone Circles	30	0	0
Artificial Islands in Highland Lochs	10	0	0
The Ductless Glands	40	0	0
Anæsthetics	20	0	0
Mental and Muscular Fatigue	25	0	0
Electromotive Phenomena in Plants	10	0	0
Dissociation of Oxy-Hæmoglobin	25	0	0
Structure of Fossil Plants	15	0	0
Experimental Study of Heredity	45	0	0
Survey of Clare Island	20	0	0
Registration of Botanical Photographs	10	0	0
Mental and Physical Factors involved in Education	10	0	0
Corresponding Societies Committee	20	0	0
	£922	0	0

REPORT OF THE COUNCIL, 1910-1911.

I. Professor E. A. Schäfer, F.R.S., has been unanimously nominated by the Council to fill the office of President of the Association for 1912 (Dundee Meeting).

II. Professor J. Perry, General Treasurer, was appointed to represent the Association at the ceremony of THEIR MAJESTIES' CORONATION.

Professor H. E. Armstrong was appointed to represent the Association at the celebration of the Centenary of the Royal Frederick University in Christiania.

III. The following NOMINATIONS are made by the Council:—

Conference of Delegates.—Professor J. W. Gregory (*Chairman*), Mr. William Dale (*Vice-Chairman*), Mr. W. P. D. Stebbing (*Secretary*).

Corresponding Societies Committee.—Mr. W. Whitaker (*Chairman*), Mr. W. P. D. Stebbing (*Secretary*), Rev. J. O. Bevan, Sir Edward Brabrook, Dr. J. G. Garson, Principal E. H. Griffiths, Dr. A. C. Haddon, Mr. T. V. Holmes, Mr. J. Hopkinson, Mr. A. L. Lewis, Mr. F. W. Rudler, Rev. T. R. R. Stebbing, and the President and General Officers of the Association.

IV. The Recommendation of the Council (embodied in its Report presented at the Sheffield Meeting) that a permanent sub-section of Agriculture be formed having been referred back to the Council, the following Committee was appointed to report to the Council on this question:—

The President.	Major P. G. Craigie.
The General Officers.	Prof. J. B. Farmer.
Sir W. Ramsay.	Mr. A. D. Hall.
Sir E. Brabrook.	Dr. A. E. Shipley.

Sir W. Tilden.

After the Report of this Committee had been received, the Council resolved by a majority to recommend:—

That Agriculture be constituted a Section of the Association.

V. In the Report of the Council for 1909-10 proposals were made as to the grouping or reorganisation of certain Sections, but these proposals were not accepted by the General Committee. The discussion upon these proposals, however, indicated the desirability of further consideration of this subject, and the Council have therefore given close attention to a series of suggestions for a revised scheme of Sectional Meetings which have been brought before them during the present year.

The Council, while resolving not to forward these suggestions to the General Committee as a recommendation, consider it desirable to bring them to the notice of the Committee in the present Report (*see Appendix*).

VI. A RESOLUTION, referred to the Council by the General Committee at Sheffield, has been received

From Section D:—

'That Section D reaffirms its resolution of September 3, 1908, and urges the Nomenclature Commission of the International Congress of Zoology to draw up an official list of generic names, with as little delay as possible, which shall not on nomenclatorial grounds be changed unless with the sanction of the Commission.'

It was resolved that no further action be taken by the Council.

VII. A Resolution, referred to the Council by the General Committee at Sheffield, has been received

From Section E:—

'That the Council be requested to bring under the notice of His Majesty's Government the high prices that recently have been fixed for many Geological Survey Maps, which tend to keep the valuable information given by these maps from being circulated as freely as it ought to be, the sale now being practically limited to persons of some means.'

The Council ordered the following Resolution to be transmitted to the Treasury:—

'The Council of the British Association desire to call the attention of the Lords Commissioners of His Majesty's Treasury to the high prices that have been recently fixed for the hand-coloured Geological Maps prepared by the Geological Survey and to the effect of this action in placing these maps out of the reach of persons of small means, and thus limiting the usefulness of that institution.

'The Council are aware that not only are recently prepared maps issued in a colour-printed form at a price which renders them readily accessible, but that old hand-coloured maps have been replaced by colour-printed editions where circumstances permitted. But they would point out that many important maps are likely to remain for a considerable time in the hand-coloured edition, and would urge My Lords to reconsider the question whether it is necessary in the meantime to raise the price of these maps to a figure which is prohibitive to many classes of the community rather than to adhere to the prices that have been in use for many years.'

A reply was received from which the following extract is made:—

Sir,— . . . I am to explain that the price of these maps was found recently to involve a substantial loss on the cost of production of each copy sold, and My Lords have felt obliged to require that the prices should be reassessed so as to cover, as in the case of other Government publications, the actual cost of production.

In these circumstances they regret to be unable to reconsider their decision on the matter.

I am, Sir,
Your obedient servant,
(*Signed*) T. L. Heath.

VIII. A Resolution, referred to the Council by the General Committee at Sheffield, has been received

From Section H:—

> 'To recommend the Council to bring to the notice of His Majesty's Secretary of State for the Colonies the defects of the present administration of antiquities in Cyprus, and to urge the necessity of prompt and efficient measures under a trained official directly responsible to the island Government to prevent destruction and spoliation of ancient remains in the island.'

It was resolved to appoint the following Committee, to advise the Council as to action, and to consider whether or not other bodies should be invited to take part in representations on the matter: the President, the General Officers, Dr. A. J. Evans, Dr. A. C. Haddon, Mr. E. Sidney Hartland, Mr. D. G. Hogarth, Professor J. L. Myres.

On the Report of this Committee, the Council resolved to proceed by way of a deputation to the Secretary of State for the Colonies, and to invite the following Societies and Institutions to co-operate by nominating representatives to join the deputation. All did so, the representatives nominated being as under:—

Society of Antiquaries	Sir A. J. Evans
Royal Archæological Institute . .	Sir H. Howorth
Hellenic Society	Prof. Ernest Gardner
British School at Athens . . .	Sir A. J. Evans
Royal Anthropological Institute . .	Dr. C. H. Read

The Council nominated the following to represent the Association, in company with the President and General Officers: Dr. A. C. Haddon, Mr. E. S. Hartland, Mr. D. G. Hogarth, Professor J. L. Myres.

The Colonial Secretary, Mr. Harcourt, received the deputation on June 27 at the Colonial Office, when there were present the President, Dr. Haddon, Mr. Hogarth, Professor Myres, Sir A. Evans, and Professor Gardner. Mr. A. Smith of the British Museum also attended. The deputation was introduced by the President, and its views were laid before Mr. Harcourt by Mr. Hogarth, Sir A. Evans, and Professor Gardner, and after some discussion had taken place, Mr. Harcourt returned a sympathetic answer to the deputation.

IX. A Resolution, referred to the Council by the General Committee at Sheffield, has been received

From Section I:—

> 'The Committee of Section I begs to call attention to the fact that during the past year resolutions have been adopted by the General Medical Council in support of early legislation to secure better regulation of the administration of general anæsthetics, and that the recent report of a Departmental Committee of the Home Office has laid special stress upon the

need of careful clinical observation controlled by physiological experiments.

'The Committee asks the Association to support such legislation and inquiry.'

It was resolved to appoint the following Committee to advise the Council as to action: Sir Lauder Brunton, Prof. W. A. Herdman, Sir W. Ramsay (President Elect), Prof. C. S. Sherrington, Dr. A. D. Waller. On the Report of this Committee, the following letter was forwarded to the Secretary of State for Home Affairs:—

SIR,—As one of the main objects of the British Association for the Advancement of Science is 'the removal of any disadvantage of a public kind,' this Council desires to support the proposals for legislation embodied in a Bill recently submitted to you by Dr. F. W. Hewitt, which Bill, we are glad to observe, has received the approval of the General Medical Council. We fully agree with the General Medical Council that in the public interest it is important for the protection of the public that legislation on the lines of this Bill should speedily take effect.

The Council of the British Association would further endorse the recommendations of the Report of the Coroners' Committee on Deaths under Anæsthetics, more particularly Recommendation 15 (asking for the formation of a small Standing Committee to acquire further knowledge concerning anæsthetics and their administration).

So fully, indeed, are we convinced of the necessity for further scientific inquiry in the matter that a Committee of this Association was formed three years ago for that purpose, and is still meeting and annually reporting to us.

Signed, on behalf of the Council,
T. G. BONNEY,
President.

X. RECOMMENDATIONS, received by the General Committee at Sheffield and referred to the Council, were dealt with as under:—

It was agreed that the following Committees be authorised to receive contributions from sources other than the Association:—

'To conduct Explorations with a view to ascertaining the Age of Stone Circles.' (*Section H.*)

'To aid investigators . . . to carry on . . . work at the Zoological Station at Naples' (*Section D.*)

XI. The following letter has been received:—

UNIVERSITY OF MANITOBA.

Winnipeg, Man., *October* 17*th*, 1910.

DEAR SIR,—I am instructed to convey to you on behalf of the Council of the University of Manitoba their hearty thanks for the generous gift of the British Association for the Advancement of Science of books to the Library of the University. Same was expressed by a unanimous vote of the Council at its last meeting on the 6th inst.

(*Signed*) W. J. SPENCE.

The Secretary, British Association for the Advancement of Science.

A set of the Annual Reports, so far as available, has been presented to the Rhodes University College, Grahamstown, South Africa.

XII. The Council have authorised Section K (Botany) to form a Sub-section for Agriculture for the Portsmouth Meeting, with a Chairman, Vice-Chairmen, and Secretariat to deal with its transactions.

XIII. The Council have received reports from the General Treasurer during the past year. His Accounts from July 1, 1910, to June 30, 1911, have been audited and are presented to the General Committee.

XIV. In accordance with the Regulations the retiring members of the Council are:—

Dr. H. T. Brown, Dr. A. E. Shipley, Dr. R. T. Glazebrook, Dr. F. W. Dyson, Mr. A. L. Bowley.

The Council nominated the following new members:—

Sir E. Brabrook,
Professor R. Meldola,
Professor F. T. Trouton,

leaving two vacancies to be filled by the General Committee without nomination by the Council.

The full list of nominations of ordinary members is as follows:—

Sir W. Abney.
Dr. Tempest Anderson.
Prof. H. E. Armstrong.
Sir E. Brabrook.
Sir Lauder Brunton.
Col. C. F. Close.
Major P. G. Craigie.
W. Crooke.
Dr. A. C. Haddon.
A. D. Hall.
E. Sidney Hartland.
Dr. J. E. Marr.
Prof. R. Meldola.
Dr. P. Chalmers Mitchell.
Prof. J. L. Myres.
Prof. E. B. Poulton.
Col. D. Prain.
Prof. C. S. Sherrington.
J. J. H. Teall.
Prof. S. P. Thompson.
Prof. F. T. Trouton.
Dr. A. E. H. Tutton.
Sir W. H. White.

XV. The General Officers have been nominated by the Council for reappointment.

XVI. The following have been admitted as members of the General Committee:—

C. W. Andrews.
J. Barcroft.
Prof. V. H. Blackman.
Prof. R. C. Bosanquet.
Prof. H. L. Bowman.
Prof. Grenville-Cole.
Prof. A. R. Cushny.
Prof. A. Dendy.
Dr. J. W. Evans.
Dr. L. N. G. Filon.
E. S. Goodrich.
J. H. Grace.
W. B. Hardy.
E. Heawood.
Capt. E. O. Henrici.
Sir T. H. Holland.
B. Hopkinson.
F. J. Lewis.
H. M. Macdonald.
D. H. Macgregor.
Dr. C. J. Martin.
H. F. Newall.
Prof. K. J. P. Orton.
Prof. C. J. Patten.
Prof. J. E. Petavel.
Prof. G. Elliot Smith.
Prof. H. B. Lees Smith.
A. G. Tansley.
Sir C. M. Watson.
Prof. T. B. Wood.

APPENDIX.

Suggestions for a Revised Scheme of Sectional Meetings.

The suggestions for a revised scheme of Sectional Meetings, referred to in the Report of the Council, § V., were as follows:—

1. The scheme had as its main object the fostering of a closer union between the Sections, by means of joint meetings, and, in general, an extension of their interests by providing greater opportunity, during the Annual Meeting, for work not confined to the individual Section-rooms.

It would also diminish the number of rooms required for the accommodation of the Association, thus lightening the expense to the place visited and making it easier to obtain rooms at a convenient distance from the Reception Room and each other.

2. The main points of the proposal were—

(i) To leave the organisation of the Sections, as at present constituted, *intact*, each having its President, officers, and committee.

(ii) To arrange the Sections in two classes—

(*a*) Those having each the exclusive use of a meeting-room for all days available for sectional work.

(*b*) Those having the exclusive use of a meeting-room for two days only out of the four full days so available, and being occupied on the other two days with joint meetings or other work as hereafter specified.

3. The following suggestions were put forward *as a basis for discussion*:—

That the Sections * be classified as follows:—

Class (*a*).—A, B, C, D.

Class (*b*).—C, E, F, G, I, K, L, M.

Between the eight Sections in class (*b*) four rooms would be divided as thus:—

On the Thursday and Monday, Sections C, E, F, and L would occupy the four rooms.

On the Friday and Tuesday, Sections G, I, K, and M would occupy the *same* four rooms.

On Thursday and Monday, Sections G, I, K, M, and on

---

* The following are the existing Sections:—

A.—Mathematics, &c.
B.—Chemistry.
C.—Geology.
D.—Zoology.
E.—Geography.
F.—Economics, &c.
G.—Engineering
H.—Anthropology.
I.—Physiology.
K.—Botany.
L.—Education.

The existence of a Section of Agriculture (M), the formation of which is recommended in the Report of the Council, is assumed for the purpose of the present argument.

Friday and Tuesday Sections C, E, F, L, might hold joint meetings:—

(*a*) Either with class (*a*) Sections in the rooms of those Sections.

(*b*) Or with the class (*b*) Sections occupying Section rooms (for nothing in this scheme is to be construed as *prohibiting* a class (*b*) Section from holding a joint meeting with any other Section on one of its own two days).

(*c*) Or with each other in a room—the 'Common Room' —set apart for the purpose. It would probably be necessary to devote a room exclusively to this, although the room used under existing arrangements by the General and other committees in the afternoons might also be made available for occupation by Sections in the mornings.

The above arrangement of the Sections in class (*b*) allots individual rooms on the same two days to Sections which commonly hold joint meetings (*e.g.*, to Sections C and E), so that such Sections would be able to use a common room for joint meetings on other days. An alternative arrangement is to allot different days for the individual meetings of kindred Sections, *e.g.*, C on Thursday and Monday, E on Friday and Tuesday. Any joint meeting between these Sections would then have to take place during the time when one or other of them was in individual occupation of a Section-room, and would thus reduce the time available for individual work. This arrangement would tend to reduce the demand upon a common room.

The present organisation of the Sections in class (*a*) would be left untouched, but their organising committees would be invited to give particular consideration to the arrangement of joint meetings with Sections in class (*b*).

4. It was assumed in drafting this scheme that all the Sections in class (*b*) would meet *regularly* in the afternoons (*e.g.*, from 2.0 to 3.30) as well as the mornings of the days on which they occupied rooms individually.

Further, the last Wednesday morning is available for sectional business, and five or six at least out of these eight Sections could be accommodated on that morning, even if meeting separately.

5. The practice of certain Sections which habitually adjourn their Section-room meetings for the purpose of carrying out field or other practical work, or visiting works, schools, &c., would afford valuable opportunities, in the case of Sections in class (*b*), for the use of time unoccupied by either individual or joint meetings.

6. The scheme makes use of eight or at most nine Section-rooms instead of twelve as at present (excluding the General Committee room).

7. Arrangements for occupation of the 'Common Room' would have to be made in advance through the office of the Association.

8. Every Section would have a permanent Committee-room for the meeting.

Dr.

THE GENERAL TREASURER IN ACCOUNT ADVANCEMENT OF SCIENCE,

1910–1911.

RECEIPTS.

	£	s.	d.
Balance brought forward	150	15	3
Life Compositions (including Transfers)	339	0	0
New Annual Members' Subscriptions	172	0	0
Annual Subscriptions	640	0	0
Sale of Associates' Tickets	551	0	0
Sale of Ladies' Tickets	122	0	0
Sale of Publications	73	4	9
Dividend on Consols	153	1	4
Dividend on India 3 per Cents.	101	14	0
Great Indian Peninsula Railway 'B' Annuity	49	4	4
Interest at Sheffield Bank	11	2	5
Unexpended Balance of Grant to Committee on the Correlation and Age of South African Strata	3	0	8

Investments.

	£	s.	d.
2½ per Cent. Consolidated Stock	6,501	10	5
India 3 per Cent. Stock	3,600	0	0
£73 Great Indian Peninsula Railway 'B' Annuity (cost)	1,493	6	6
	11,594	16	11
Sir Frederick Bramwell's Gift:— 2½ per Cent. Self-cumulating Consolidated Stock	71	6	10
[To be awarded in 1931 for a paper 'dealing with the whole question of the prime movers of 1931, and especially with the then relation between steam engines and internal-combustion engines.']			
	£11,666	3	9

£	s.	d.
£2,366	2	9

JOHN PERRY, *General Treasurer.*

WITH THE BRITISH ASSOCIATION FOR THE *Cr.*

July 1, 1910, to June 30, 1911.

1910-1911. PAYMENTS.

	£	s.	d.	£	s.	d.
Rent and Office Expenses				98	0	3
Salaries, &c.				670	10	1
Printing, Binding, &c.				225	8	7
Expenses of Sheffield Meeting				96	15	5
Payment of Grants made at Sheffield:—						
Seismological Investigations	60	0	0			
Magnetic Observations at Falmouth	25	0	0			
Investigation of the Upper Atmosphere	25	0	0			
Grant to International Commission on Physical and Chemical Constants	30	0	0			
Study of Hydro-aromatic Substances	20	0	0			
Dynamic Isomerism	25	0	0			
Transformation of Aromatic Nitroamines	15	0	0			
Electroanalysis	15	0	0			
Influence of Carbon, &c., on Corrosion of Steel	15	0	0			
Crystalline Rocks of Anglesey	2	0	0			
Mammalian Fauna in Miocene Deposits, Bugti Hills, Baluchistan	75	0	0			
Table at the Zoological Station at Naples	100	0	0			
Index Animalium	75	0	0			
Feeding Habits of British Birds	5	0	0			
Belmullet Whaling Station	30	0	0			
Map of Prince Charles Foreland	30	0	0			
Gaseous Explosions	90	0	0			
Lake Villages in the neighbourhood of Glastonbury	5	0	0			
Age of Stone Circles	30	0	0			
Artificial Islands in Highland Lochs	10	0	0			
The Ductless Glands	40	0	0			
Anæsthetics	20	0	0			
Mental and Muscular Fatigue	25	0	0			
Electromotive Phenomena in Plants	10	0	0			
Dissociation of Oxy-Hæmoglobin	25	0	0			
Structure of Fossil Plants	15	0	0			
Experimental Study of Heredity	45	0	0			
Survey of Clare Island	20	0	0			
Registration of Botanical Photographs	10	0	0			
Mental and Physical Factors involved in Education	10	0	0			
Corresponding Societies Committee	20	0	0			
				922	0	0
				£2,012	9	4
Balance at Bank of England (Western Branch)	428	0	11			
Less Cheques not presented	77	0	0			
	£351	0	11			
Cash not paid in	2	19	10			
	£354	0	9			
Less Petty Cash overspent		7	4			
				353	13	5
				£2,366	2	9

An account of about £800 is outstanding due to Messrs. Spottiswoode & Co.

I have examined the above Account with the Books and Vouchers of the Association, and certify the same to be correct. I have also verified the Balance at the Bankers, and have ascertained that the Investments are registered in the names of the Trustees.

Approved—
HERBERT MCLEOD, } *Auditors.*
EDWARD BRABROOK, }
Aug. 9, 1911.

W. B. KEEN, *Chartered Accountant.*

1911.

GENERAL MEETINGS AT PORTSMOUTH.

On Wednesday, August 30, at 8.30 P.M., in the Town Hall, the Rev. Professor T. G. Bonney, F.R.S., resigned the office of President to Sir William Ramsay, K.C.B., F.R.S., who took the Chair and delivered an Address, for which see p. 3.

On Thursday, August 31, at 2.30 P.M., a visit was made to His Majesty's Dockyard; and at 8.30 P.M. the Mayor and Mayoress (Alderman and Mrs. T. Scott Foster) held a Reception at the South Parade Pier.

On Friday, September 1, at 8.30 P.M., in the Town Hall, Mr. Leonard Hill, F.R.S., delivered a Discourse on 'The Physiology of Submarine Work' (p. 634).

On Monday, September 4, at 2.15 P.M., members assembled on board H.M.S. *Revenge*, which proceeded to Spithead and was attacked by torpedo-boats and submarines. At 8.30 P.M., in the Town Hall, Professor A. C. Seward delivered a Discourse on 'Links with the Past in the Plant World' (p. 647).

On Tuesday, September 5, at 3 P.M., the Mayor and Mayoress gave a Garden Party in Victoria Park.

On Wednesday, September 6, at 3 P.M., the concluding General Meeting was held in the Town Hall, when the following Resolutions were adopted:—

1. That the grateful thanks of the Association be given to Alderman T. Scott Foster, Mayor of Portsmouth, for the reception and generous hospitality accorded to its members on the occasion of this meeting.

2. That a cordial vote of thanks be given to the Commander-in-Chief and men of the Royal Navy for the splendid naval display to which they have treated the members of the Association.

3. That a cordial vote of thanks be given to the Corporation and citizens of Portsmouth for the reception which they have accorded to the British Association, and to the Directors of the Borough of Portsmouth Waterworks Company, the Portsea Island Gas Light Company, and Corporation Committees for the facilities offered to the members for the inspection of their respective works.

4. That a cordial vote of thanks be given to the Local Officers and Executive Committees for the admirable arrangements made for the meeting.

OFFICERS OF SECTIONAL COMMITTEES PRESENT AT THE PORTSMOUTH MEETING.

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

President.—Prof. H. H. Turner, F.R.S. *Vice-Presidents.*—Prof. J. C. Fields; Prof. W. M. Hicks, F.R.S.; Prof. A. E. H. Love, F.R.S.; Dr. W. N. Shaw, F.R.S.; Prof. F. T. Trouton, F.R.S. *Secretaries.*—Prof. A. W. Porter, F.R.S. (*Recorder*); H. Bateman, M.A.; Dr. P. V. Bevan; A. S. Eddington, M.A.; E Gold, M.A.; P. A. Yapp.

SECTION B.—CHEMISTRY.

President.—Prof. J. Walker, D.Sc., F.R.S. *Vice-Presidents.*—Prof. A. Béhal; Prof. A. Haller; Prof. W. J. Pope, F.R.S.; Prof. A. Senier, M.D.; J. E. Stead, F.R.S. *Secretaries.*—Dr. E. F. Armstrong (*Recorder*); Dr. F. Beddow, D.Sc.; Dr. C. H. Desch; Dr. T. M. Lowry.

SECTION C.—GEOLOGY.

President.—A. Harker, M.A., F.R.S. *Vice-Presidents.*—Dr. C. W. Andrews, F.R.S.; G. Barrow; Dr. E. Hull, F.R.S.; Dr. F. W. Hume; Clement Reid, F.R.S.; W. Whitaker, F.R.S. *Secretaries.*—W. Lower Carter, M.A. (*Recorder*); Lieut.-Col. C. W. Bevis; Dr. A. R. Dwerryhouse; Prof. S. H. Reynolds, M.A.

SECTION D.—ZOOLOGY.

President.—Prof. D'Arcy W. Thompson, C.B. *Vice-Presidents.*—Prof. G. C. Bourne, F.R.S.; W. T. Calman, D.Sc.; Prof. Maurice Caullery; Dr. P. P. C. Hoek; Prof. H. Jungersen; G. Archdall Reid, M.B. *Secretaries.*—Dr. H. W. Marett Tims, M.A., M.D. (*Recorder*); Dr. J. H. Ashworth, D.Sc.; C. Foran; R. Douglas Laurie, M.A.

SECTION E.—GEOGRAPHY.

President.—Colonel C. F. Close, C.M.G., R.E. *Vice-Presidents.*—Prof. H. N. Dickson, D.Sc.; Prof. A. J. Herbertson, Ph.D.; Colonel Sir D. A. Johnston, K.C.M.G., R.E.; Captain H. G. Lyons, F.R.S.; M. A. Stein, C.I.E., Ph.D.; A. Silva White. *Secretaries.*—J. McFarlane, M.A. (*Recorder*); E. A. Reeves; W. Parnell Smith.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

President.—Hon. W. Pember Reeves. *Vice-Presidents.*—Sir Edward Brabrook, C.B.; Prof. S. J. Chapman, M.Com., M.A.; Right Hon. Sir George H. Reid, G.C.M.G.; Sir H. Llewellyn Smith, K.C.B., M.A. *Secretaries.*—Dr. W. R. Scott, M.A. (*Recorder*); C. R. Fay, M.A.; H. A. Stibbs.

SECTION G.—ENGINEERING.

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Chairman.—Prof. J. W. Gregory, F.R.S. *Vice-Chairman.*—William Dale. *Secretary.*—W. P. D. Stebbing.

COMMITTEE OF RECOMMENDATIONS.

The President and Vice-Presidents of the Association; the General Secretaries; the General Treasurer; the Trustees; the Presidents of the Association in former years; the Chairman of the Conference of Delegates; Prof. H. H. Turner; Prof. W. M. Hicks; Prof. J. Walker; Dr. E. F. Armstrong; A. Harker; W. Lower Carter; Prof. D'Arcy Thompson; Dr. Marett Tims; Colonel C. F. Close: J. McFarlane; Hon. W. Pember Reeves; Dr. W. R. Scott; Prof. J. H. Biles; Prof. E. G. Coker; Dr. W. H. R. Rivers; E. N. Fallaize; Prof. J. S. Macdonald; Dr. H. E. Roaf; Prof. F. E. Weiss; Prof. R. H. Yapp; Rt. Rev. J. E. C. Welldon; J. L. Holland and A. D. Hall.

RESEARCH COMMITTEES, ETC., APPOINTED BY THE GENERAL COMMITTEE AT THE PORTSMOUTH MEETING: SEPTEMBER 1911.

1. *Receiving Grants of Money.*

Subject for Investigation, or Purpose	Members of Committee	Grants		
SECTION A.—MATHEMATICS AND PHYSICS		£	s.	d.
Seismological Observations.	*Chairman.*—Professor H. H. Turner. *Secretary.*—Dr. J. Milne. Mr. C. V. Boys, Sir George Darwin, Mr. Horace Darwin, Major L. Darwin, Dr. R. T. Glazebrook, Mr. M. H. Gray, Mr. R. K. Gray, Professors J. W. Judd, C. G. Knott, and R. Meldola, Mr. R. D. Oldham, Professor J. Perry, Mr. W. E. Plummer, Dr. R. A. Sampson, and Professor A. Schuster.	60	0	0
To co-operate with the Committee of the Falmouth Observatory in their Magnetic Observations.	*Chairman.*—Sir W. H. Preece. *Secretary.*—Dr. W. N. Shaw. Professor W. G. Adams, Captain Creak, Mr. W. L. Fox, Dr. R. T. Glazebrook, Professor A. Schuster, Sir A. W. Rücker, and Dr. Charles Chree.	25	0	0
To aid the work of Establishing a Solar Observatory in Australia.	*Chairman.*—Sir David Gill. *Secretary.*—Dr. W. G. Duffield. Rev. A. L. Cortie, Dr. W. J. S. Lockyer, Mr. F. McClean, and Professors A. Schuster and H. H. Turner.	50	0	0
Investigation of the Upper Atmosphere.	*Chairman.*—Dr. W. N. Shaw. *Secretary.*—Mr. E. Gold. Mr. D. Archibald, Mr. C. Vernon Boys, Mr. C. J. P. Cave, Mr. W. H. Dines, Dr. R. T. Glazebrook, Professor J. E. Petavel, Dr. A. Schuster, Dr. W. Watson, and Sir J. Larmor.	30	0	0
Grant to the International Commission on Physical and Chemical Constants.	*Chairman.*—Sir W. Ramsay. *Secretary.*—Dr. N. T. M. Wilsmore.	80	0	0

1. *Receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee	Grants		
		£	s.	d.
The further Tabulation of Bessel and other Functions.	*Chairman.*—Professor M. J. M. Hill. *Secretary.*—Dr. J. W. Nicholson, Mr. J. R Airey, Professor Alfred Lodge, Dr. L. N. G. Filon, and Sir G. Greenhill.	15	0	0

SECTION B.—CHEMISTRY.

The Study of Hydro-aromatic Substances.	*Chairman.*—Professor E. Divers. *Secretary.*—Professor A. W. Crossley. Professor W. H. Perkin, Dr. M. O. Forster, and Dr. Le Sueur.	20	0	0
Dynamic Isomerism.	*Chairman.*—Professor H. E. Armstrong. *Secretary.*—Dr. T. M. Lowry. Professor Sydney Young, Dr. Desch, Dr. J. J. Dobbie, and Dr. M. O. Forster.	30	0	0
The Transformation of Aromatic Nitroamines and allied substances, and its relation to Substitution in Benzene Derivatives.	*Chairman.*—Professor F. S. Kipping. *Secretary.*—Professor K. J. P. Orton. Dr. S. Ruhemann, and Dr. J. T. Hewitt.	10	0	0
Electroanalysis.	*Chairman.*—Professor F. S. Kipping. *Secretary.*—Dr. F. M. Perkin. Dr. G. T. Beilby, Dr. T. M. Lowry, Professor W. J. Pope, and Dr. H. J. S. Sand.	10	0	0
The Study of Plant Enzymes, particularly with relation to Oxidation.	*Chairman.*—Mr. A. D. Hall. *Secretary.*—Dr. E. F. Armstrong. Professor H. E. Armstrong, Professor F. Keeble, and Dr. E. J. Russell.	30	0	0

SECTION C.—GEOLOGY.

To investigate the Erratic Blocks of the British Isles, and to take measures for their preservation.	*Chairman.*—Mr. R. H. Tiddeman. *Secretary.*—Dr. A. R. Dwerryhouse. Dr. T. G. Bonney, Mr. F. M. Burton, Mr. F. W. Harmer, Rev. S. N. Harrison, Dr. J. Horne, Mr. W. Lower Carter, Professor W. J. Sollas, and Messrs. W. Hill, J. W. Stather, and J. H. Milton.	5	0	0
To excavate Critical Sections in the Palæozoic Rocks of Wales and the West of England.	*Chairman.*—Professor C. Lapworth. *Secretary.*—Mr. W. G. Fearnsides. Dr. J. E. Marr, Professor W. W. Watts, and Mr. G. J. Williams.	10	0	0

1. *Receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee	Grants		
		£	s.	d.
To investigate the Microscopical and Chemical Composition of Charnwood Rocks.	*Chairman.* — Professor W. W. Watts. *Secretary.*—Dr. T. T. Groom. Dr. F. W. Bennett and Dr. Stracey.	2	0	0
The Investigation of the Igneous and Associated Rocks of Glensaul and Lough Nafooey Areas, Co. Galway.	*Chairman.* — Professor W. W. Watts. *Secretary.*—Professor S. H. Reynolds. Messrs. R G. Carruthers and C. I. Gardiner.	15	0	0
To consider the preparation of a List of Characteristic Fossils.	*Chairman.*—Professor P. F. Kendall. *Secretary.*—Mr. W. Lower Carter. Mr. H. L Allen, Professor W. S. Boulton, Professor G. Cole, Dr A. R. Dwerryhouse, Professors J. W. Gregory, Sir T. H. Holland, G. A. Lebour, and S. H. Reynolds, Dr Marie C. Stopes, Mr. Cosmo Johns, Dr. J. E Marr, Dr. A. Vaughan, Professor W. W. Watts, Mr. H. Woods, and Dr. A. Smith Woodward.	5	0	0
To investigate the Bone Bed at the base of the Coralline Crag at Sutton, with special reference to the occurrence of Chipped Flints therein.	*Chairman.*—Sir E. Ray Lankester. *Secretary.*—Mr. E. P. Ridley. Mr. W. Whitaker.	15	0	0
To investigate the occurrence of the Bembridge Limestone at Creechbarrow Hill.	*Chairman.*—Professor T. McK. Hughes. *Secretary.*—Mr H. Woods. Dr. J. J. H. Teall, Dr. J. E. Marr, Professor E. J. Garwood, Mr. C. Reid, Mr. W. Whitaker and Mr. H. A. Allen.	20	0	0

SECTION D.—ZOOLOGY.

Subject for Investigation, or Purpose	Members of Committee	£	s.	d.
To aid competent Investigators selected by the Committee to carry on definite pieces of work at the Zoological Station at Naples.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Mr. E. S. Goodrich. Sir E. Ray Lankester, Professor A. Sedgwick, Professor W. C. McIntosh, Dr. S. F. Harmer, Mr. G. P. Bidder, Dr. W B Hardy, and Professor A. D. Waller.	30	0	0
Compilation of an Index Generum et Specierum Animalium.	*Chairman.*—Dr. H. Woodward. *Secretary.*—Dr. F. A. Bather. Dr. P. L. Sclater, Rev. T. R. R. Stebbing, Dr. W. E. Hoyle, the Hon. Walter Rothschild, Lord Walsingham and Dr. Calman.	75	0	0

1. *Receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee	Grants
		£ s. d.
To investigate the Biological Problems incidental to the Belmullet Whaling Station.	*Chairman.*—Dr. A. E. Shipley. *Secretary.*—Professor J. Stanley Gardiner. Professor W. A. Herdman, Rev. W. Spotswood Green, Mr. E. S. Goodrich, Dr. H. W. Marett Tims, and Mr. R. M. Barrington.	20 0 0
To defray expenses connected with work on the Inheritance and development of Secondary Sexual Characters in Birds.	*Chairman.*—Professor G. C. Bourne. *Secretary.*—Mr. Geoffrey Smith. Mr. E. S. Goodrich, Dr. W. T. Calman, and Dr. Marett Tims.	10 0 0

SECTION E.—GEOGRAPHY.

Subject for Investigation, or Purpose	Members of Committee	Grants
Upon a new series of equal area maps, to measure areas of vertical relief, vegetation, and rainfall; to calculate the mean levels of the sphere, the continents and the oceans, and the total mean annual rainfall over the lands.	*Chairman.*—Professor A. J. Herbertson. *Secretary.*—Mr. E. A. Reeves. Dr. H. R. Mill, Mr. G. G. Chisholm, and Colonel C. F. Close.	20 0 0
Calculation of areas of 10′ squares on the Spheroid.[1]	*Chairman.*—Colonel C. F. Close. *Secretary.*—Mr. E. A. Reeves. Captain H. G. Lyons.	25 0 0

SECTION G.—ENGINEERING.

Subject for Investigation, or Purpose	Members of Committee	Grants
The Investigation of Gaseous Explosions, with special reference to Temperature.	*Chairman.*—Sir W. H. Preece. *Secretaries.*—Mr. Dugald Clerk and Professor B. Hopkinson. Professors W. A. Bone, F. W. Burstall, H. L. Callendar, E. G. Coker, W. E. Dalby, and H. B. Dixon, Drs. R. T. Glazebrook and J. A. Harker, Colonel H. C. L. Holden, Professor J. E. Petavel, Captain H. Riall Sankey, Professor A. Smithells, Professor W. Watson, Mr. D. L. Chapman, and Mr. H. E. Wimperis.	60 0 0

SECTION H.—ANTHROPOLOGY.

Subject for Investigation, or Purpose	Members of Committee	Grants
To investigate the Lake Villages in the neighbourhood of Glastonbury in connection with a Committee of the Somerset Archæological and Natural History Society.	*Chairman.*—Dr. R. Munro. *Secretary.*—Professor W. Boyd Dawkins. Professor W. Ridgeway, Sir Arthur J. Evans, Dr. C. H. Read, Mr. H. Balfour, and Dr. A. Bulleid.	5 0 0
To conduct Explorations with the object of ascertaining the Age of Stone Circles.	*Chairman.*—Dr. C. H. Read. *Secretary.*—Mr. H. Balfour. Dr. G. A. Auden, Lord Avebury, Professor W. Ridgeway, Dr. J. G. Garson, Sir A. J. Evans, Dr. R. Munro, Professor Boyd Dawkins, and Mr. A. L. Lewis.	15 0 0

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[1] It was subsequently ascertained that this work had been carried out elsewhere, and the Committee was dissolved.

1. *Receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee	Grants		
		£	s.	d.
To prepare a New Edition of Notes and Queries in Anthropology.	*Chairman.*—Dr. C. H. Read. *Secretary.*—Professor J. L. Myres. Mr. E. N. Fallaize, Dr. A. C. Haddon, Mr. T. A. Joyce, and Drs. C. S. Myers, W. H. R. Rivers, C. G. Seligmann, and F. C. Shrubsall.	40	0	0
To investigate and ascertain the Distribution of Artificial Islands in the lochs of the Highlands of Scotland.	*Chairman.*—Dr. R. Munro. *Secretary.*—Professor J. L. Myres. Professors T. H. Bryce, W. Boyd Dawkins, and W. Ridgeway.	13	0	0
To investigate the Physical Characters of the Ancient Egyptians.	*Chairman.*—Professor G. Elliot Smith. *Secretary.*—Dr. F. C. Shrubsall. Dr. A. Keith and Dr. C. G. Seligmann.	40	0	0
To conduct Excavations in Easter Island.	*Chairman.*—Dr. A. C. Haddon. *Secretary.*—Dr. W. H. R. Rivers. Mr. R. R. Marett and Dr. C. G. Seligmann.	15	0	0
To organise Anthropometric Investigations in the British Isles.	*Chairman.*—Professor A. Thomson. *Secretary.*—Mr. J. Gray. Dr. F. C. Shrubsall.	5	0	0

SECTION I.—PHYSIOLOGY.

Subject for Investigation, or Purpose	Members of Committee	£	s.	d.
The Ductless Glands.	*Chairman.*—Professor Schäfer. *Secretary.*—Professor Swale Vincent. Professor A. B. Macallum, Dr. L. E. Shore, and Mrs. W. H. Thompson.	35	0	0
To aid competent Investigators selected by the Committee to carry on definite pieces of work at the Zoological Station at Naples.	*Chairman.*—Professor S. J. Hickson. *Secretary.*—Mr. E. S. Goodrich. Sir E. Ray Lankester, Professor A. Sedgwick, Professor W. C. McIntosh, Dr. S. F. Harmer, Mr. G. P. Bidder, Dr. W. B. Hardy, and Professor A. D. Waller.	20	0	0
To acquire further knowledge, Clinical and Experimental, concerning Anæsthetics—especially Chloroform, Ether, and Alcohol—with special reference to Deaths by or during Anæsthesia, and their possible diminution.	*Chairman.*—Dr. A. D. Waller. *Secretary.*—Sir F. W. Hewitt. Dr. Blumfeld, Mr. J. A. Gardner, and Dr. G. A. Buckmaster.	20	0	0

1. *Receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee	Grants		
		£	s.	d.
Calorimetric Observations on Man in Health and in Febrile Conditions.	*Chairman.*—Professor J. S. Macdonald. *Secretary.*—Dr. G. Chapman. Dr. Keith Lucas.	40	0	0
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The Structure of Fossil Plants.	*Chairman.*—Professor F. W. Oliver. *Secretary.*—Professor F. E. Weiss. Mr. E. Newell Arber, Professor A. C. Seward, and Dr. D. H. Scott.	15	0	0
The Experimental Study of Heredity.	*Chairman.*—Mr. Francis Darwin. *Secretary.*—Mr. A. G. Tansley. Professors Bateson and Keeble.	35	0	0
A Botanical, Zoological, and Geological Survey of Clare Island.	*Chairman.*—Professor T. Johnson. *Secretary.*—Mr. R. Lloyd Praeger. Professor Grenville Cole, Dr. Scharff, and Mr. A. G. Tansley.	20	0	0
The Investigation of the Jurassic Flora of Yorkshire.	*Chairman.*—Professor A. C. Seward. *Secretary.*—Mr. H. Hamshaw Thomas. Mr. H. W. T. Wager and Professor F. E. Weiss.	20	0	0
SECTION L.—EDUCATIONAL SCIENCE.				
To inquire into and report upon the methods and results of research into the Mental and Physical Factors involved in Education.	*Chairman.*—Professor J. J. Findlay. *Secretary.*—Professor J. A. Green. Professor J. Adams, Dr. G. A. Auden, Sir E. Brabrook, Dr. W. Brown, Professor E. P. Culverwell, Mr. G. F. Daniell, Miss B. Foxley, Mr. J. Gray, Professor R. A. Gregory, Dr. C. W. Kimmins, Professor W. MacDougall, Dr. C. S. Myers, Dr. T. P. Nunn, Dr. W. H. R. Rivers, Dr. F. C. Shrubsall, Mr. H. Bompas Smith, Dr. C. Spearman, and Dr. F. Warner.	5	0	0
To inquire into and report upon the overlapping between Secondary Education and that of Universities and other places of Higher Education.	*Chairman.*—Principal Miers. *Secretary.*—Professor R. A. Gregory. Messrs. D. Berridge and C. H. Bothamley, Miss L. J. Clarke, Miss A. J. Cooper, Miss B. Foxley, Principal E. H. Griffiths, and Professor Smithells.	5	0	0

1. *Receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee	Grants
		£ *s.* *d.*
To inquire into the Curricula and Educational Organisation of Industrial and Poor Law Schools with special reference to Day Industrial Schools.	*Chairman.*—Mr. W. D. Eggar. *Secretary.*—Mrs. W. N. Shaw. Professor R. A. Gregory, Mr. J. L. Holland, Dr. C. W. Kimmins, and Mr. J. G. Legge.	10 0 0
The Influence of School Books upon Eyesight.	*Chairman.*—Dr. G. A. Auden. *Secretary.*—Mr. G. F. Daniell. Mr. C. H. Bothamley, Mr W. D. Eggar, Professor R A. Gregory, Mr. J. L. Holland, Professor Priestley Smith, and Mr. Trevor Walsh.	5 0 0

CORRESPONDING SOCIETIES.

Corresponding Societies Committee for the preparation of their Report.	*Chairman.*—Mr. W. Whitaker. *Secretary.*—Mr. W. P. D. Stebbing. Rev. J. O. Bevan, Sir Edward Brabrook, Dr. J. G. Garson, Principal E. H. Griffiths, Dr. A. C. Haddon, Mr. T. V. Holmes, Mr. J. Hopkinson, Mr. A. L. Lewis, Mr. F. W. Rudler, Rev. T. R. R. Stebbing, and the President and General Officers of the Association.	25 0 0

SPECIAL GRANT.

To co-operate with Local Bodies in acquiring and arranging Collections to illustrate the Natural History, Geography, and Antiquities of the Isle of Wight.	*Chairman.*—Mr. Clement Reid. *Secretary.*—Professor J. L. Myres Mr. O. G. S. Crawford, Mr. W. Dale, Professor E. B. Poulton, and Dr. A. B. Rendle.	10 0 0

2. *Not receiving Grants of Money.*

Subject for Investigation, or Purpose	Members of Committee
SECTION A.—MATHEMATICS AND PHYSICS.	
Making Experiments for improving the Construction of Practical Standards for use in Electrical Measurements.	*Chairman.*—Lord Rayleigh. *Secretary.*—Dr. R. T. Glazebrook. Professors J. Perry and W. G. Adams, Dr. G. Carey Foster, Sir Oliver Lodge, Dr. A. Muirhead, Sir W. H. Preece, Professor A. Schuster, Dr. J. A. Fleming, Professor Sir J. J. Thomson, Dr. W. N. Shaw, Dr. J. T. Bottomley, Rev. T. C. Fitzpatrick, Professor S. P. Thompson, Mr. J. Rennie, Principal E. H. Griffiths, Sir Arthur Rücker, Professor H. L. Callendar, and Messrs. G. Matthey, T. Mather, and F. E. Smith.
SECTION C.—GEOLOGY.	
The Collection, Preservation, and Systematic Registration of Photographs of Geological Interest.	*Chairman.*—Professor J. Geikie. *Secretaries.*—Professors W. W. Watts and S. H. Reynolds. Dr. T. Anderson, Mr. G. Bingley, Dr. T. G. Bonney, Mr. C. V. Crook, Professor E. J. Garwood, and Messrs. W. Gray, R. Kidston, A. S. Reid, J. J. H. Teall, R. Welch, W. Whitaker, and H. B. Woodward.
To enable Mr. E. Greenly to complete his Researches on the Composition and Origin of the Crystalline Rocks of Anglesey.	*Chairman.*—Mr. A. Harker. *Secretary.*—Mr. E. Greenly. Dr. J. Horne, Dr. C. A. Matley, and Professor K. J. P. Orton.
SECTION D.—ZOOLOGY.	
To investigate the Feeding Habits of British Birds by a study of the contents of the crops and gizzards of both adults and nestlings, and by collation of observational evidence, with the object of obtaining precise knowledge as to the economic status of many of our commoner birds affecting rural science.	*Chairman.*—Dr. A. E. Shipley. *Secretary.*—Mr. H. S. Leigh. Messrs. J. N. Halbert, Robert Newstead, Clement Reid, A. G. L. Rogers, and F. V. Theobald, Professor F. E. Weiss, Dr. C. Gordon Hewitt, and Professors S. J. Hickson, F. W. Gamble, G. H. Carpenter, and J. Arthur Thomson.
To continue the Investigation of the Zoology of the Sandwich Islands, with power to co-operate with the Committee appointed for the purpose by the Royal Society, and to avail themselves of such assistance in their investigations as may be offered by the Hawaiian Government or the Trustees of the Museum at Honolulu. The Committee to have power to dispose of specimens where advisable.	*Chairman.*—Dr. F. Du Cane Godman. *Secretary.*—Dr. David Sharp. Professor S. J. Hickson, Dr. P. L. Sclater, and Mr. Edgar A. Smith.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee
To summon meetings in London or elsewhere for the consideration of matters affecting the interests of Zoology or Zoologists, and to obtain by correspondence the opinion of Zoologists on matters of a similar kind, with power to raise by subscription from each Zoologist a sum of money for defraying current expenses of the Organisation.	*Chairman.*—Sir E. Ray Lankester. *Secretary.*—Professor S. J. Hickson. Professors G. C. Bourne, J. Cossar Ewart, M. Hartog, W. A. Herdman, and J. Graham Kerr, Mr. O. H. Latter, Professor Minchin, Dr. P. C. Mitchell, Professors E. B. Poulton and A. Sedgwick, and Dr. A. E. Shipley.
To nominate competent naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.	*Chairman* and *Secretary.*—Professor A. Dendy. Sir E. Ray Lankester, Professor A. Sedgwick, Professor Sydney H. Vines, and Mr. E. S. Goodrich.
To enable Mr. Laurie to conduct Experiments in Inheritance.	*Chairman.*—Professor W. A. Herdman. *Secretary.*—Mr. Douglas Laurie. Professor R. C. Punnett and Dr. H. W. Marett Tims.
To formulate a Definite System on which Collectors should record their captures.	*Chairman.*—Professor J. W. H. Trail. *Secretary.*—Mr. F. Balfour Browne. Dr. Scharff, Professor G. H. Carpenter, Professor E. B. Poulton, and Messrs. A. G. Tansley and R. Ll. Praeger.

SECTION H.—ANTHROPOLOGY.

Subject for Investigation, or Purpose	Members of Committee
The Collection, Preservation and Systematic Registration of Photographs of Anthropological Interest.	*Chairman.*—Dr. C. H. Read. *Secretary.*—Mr. H. S. Kingsford. Dr. G. A. Auden, Mr. E. Heawood, and Professor J. L. Myres.
To excavate Neolithic Sites in Northern Greece.	*Chairman.*—Professor W. Ridgeway. *Secretary.*—Professor J. L. Myres. Mr. J. P. Droop and Mr. D. G. Hogarth.
To conduct Archæological and Ethnological Researches in Crete.	*Chairman.*—Mr. D. G. Hogarth. *Secretary.*—Professor J. L. Myres. Professor R. C. Bosanquet, Dr. W. L. H. Duckworth, Sir A. J. Evans, Professor W. Ridgeway, and Dr. F. C. Shrubsall.
To co-operate with Local Committees in Excavations on Roman Sites in Britain.	*Chairman.*—Professor W. Ridgeway. *Secretary.*—Professor J. L. Myres. Dr. T. Ashby.
To report on the present state of knowledge of the Prehistoric Civilisation of the Western Mediterranean with a view to future research.	*Chairman.*—Professor W. Ridgeway. *Secretary.*—Professor J. L. Myres. Dr. T. Ashby, Dr. W. L. H. Duckworth, Mr. D. G. Hogarth, and Sir A. J. Evans.
To co-operate with a local Committee in the excavation of a prehistoric site at Bishop's Stortford.	*Chairman.*—Professor W. Ridgeway. *Secretary.*—Rev. Dr. A. Irving. Dr. A. C. Haddon and Dr. H. W. Marett Tims.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee
Section I.—PHYSIOLOGY.	
Effect of Low Temperature on Cold-blooded Animals.	*Chairman.*—Professor Swale Vincent. *Secretary.*—Mr. A. T. Cameron.
The Effect of Climate upon Health and Disease.	*Chairman.*—Sir T. Lauder Brunton. *Secretaries.*—Mr. J. Barcroft and Lieut.-Col. Simpson Colonel Sir D. Bruce, Dr. S. G. Campbell, Sir Kendal Franks, Professor J. G. McKendrick, Sir A. Mitchell, Dr. Porter, Dr. J. L. Todd, Professor Sims Woodhead, and the Heads of the Tropical Schools of Liverpool, London, and Edinburgh.
Electromotive Phenomena in Plants.	*Chairman.*—Dr. A. D. Waller. *Secretary*—Mrs. Waller. Professors F. Gotch, J. B. Farmer, and Veley, and Dr. F. O'B. Ellison.
The Dissociation of Oxy-Hæmoglobin at High Altitudes.	*Chairman.*—Professor E. H. Starling. *Secretary*—Dr. J. Barcroft. Dr. W. B. Hardy.
Body Metabolism in Cancer.	*Chairman.*—Professor C. S. Sherrington. *Secretary.*—Dr. S. M. Copeman.
Mental and Muscular Fatigue.	*Chairman.*—Dr. W. MacDougall. *Secretary.*—Miss Edgell. Dr. A. D. Waller and Dr. C. S. Myers.
Section K.—BOTANY.	
To consider the promotion of the Study of the Plant Life of the British Islands, and the preparation of the materials for a National Flora.	*Chairman.*—Professor J. W. H. Trail. *Secretary.*—Professor R. H. Yapp. Colonel D. Prain, Professor I. Bayley Balfour, Mr. R. Lloyd Praeger, Mr. A. B. Rendle, Dr. W. G. Smith, and Mr. A. G. Tansley.
To consider and report on the advisability and the best means of securing definite Areas for the Preservation of types of British Vegetation.	*Chairman.*—Professor F. E. Weiss. *Secretary.*—Mr. A. G. Tansley, Professor J. W. H. Trail, Mr. R. Lloyd Praeger, Professor F. W. Oliver, Professor R. W. Phillips, Dr. C. E. Moss, and Mr. G. C. Druce.
To carry out the scheme for the Registration of Negatives of Botanical Photographs.	*Chairman.*—Professor F. W. Oliver. *Secretary.*—Professor F. E. Weiss. Dr. W. G. Smith, Mr. A. G. Tansley, Dr. T. W. Woodhead, and Professor R. H. Yapp.

2. *Not receiving Grants of Money*—continued.

Subject for Investigation, or Purpose	Members of Committee
SECTION L.—EDUCATIONAL SCIENCE.	
To take notice of, and report upon changes in, Regulations—whether Legislative, Administrative, or made by Local Authorities — affecting Secondary Education.	*Chairman.*—Sir Philip Magnus. *Secretary.*—Professor H. E. Armstrong. Miss Coignou, Sir Henry Craik, Principal Griffiths, Sir Horace Plunkett, Mr. H. Ramage, Professor M. E. Sadler, and Rt. Rev. J. E. C. Welldon.
To report upon the Course of Experimental, Observational, and Practical Studies most suitable for Elementary Schools.	*Chairman.*—Sir Philip Magnus. *Secretary.*—Mr. W. M. Heller. Sir W. de W. Abney, Mr. R. H. Adie, Professor H. E. Armstrong, Miss L. J. Clarke, Miss A. J. Cooper, Mr. George Fletcher, Professor R. A. Gregory, Principal Griffiths, Mr. A. D. Hall, Dr. A. J. Herbertson, Dr. C. W. Kimmins, Professor L. C. Miall, Professor J. Perry, Mrs. W N. Shaw, Professor A. Smithells, Dr. Lloyd Snape, Sir H. R. Reichel, Mr. H. Richardson, and Professor W. W. Watts.
The Aims and Limits of Examinations.	*Chairman.*—Professor M. E. Sadler. *Secretary.*—Mr. P. J. Hartog. Mr. D. P. Berridge, Mr. W. D. Eggar, Professor R. A. Gregory, Principal E. H. Griffiths, Miss C. L. Laurie, Dr W. McDougall, Dr. T. P. Nunn, Sir W. Ramsay, Rt. Rev. J. E. C. Welldon, and Dr. Jessie White.

Communications ordered to be printed in extenso.

Section A.—Mr. Cunningham. The Principle of Relativity.
" Mr. Eddington. Stellar Distribution and Movements.
Section B.—Professor A. McWilliam. Report on Electric Steel Furnaces.
" Mr. Tizard. The Sensitiveness of Indicators.
Section D.—Professor A. Dendy. Momentum in Evolution.
Section G.—Professor G. W. O. Howe. Recent Developments in Radiotelegraphy.[1]
Section I.—Dr. Chick and Dr. Martin. Heat Coagulation of Proteins.
" Dr. A. D. Waller. Claims of Sir Charles Bell to the Anatomical Distinction of Motor and Sensory Nerves.

Resolutions referred to the Council for consideration, and, if desirable, for action.

From Sections D and H.

That the Council be approached with the view of requesting His Majesty's Government to equip a vessel for the purpose of making a Biological and Anthropological Exploration in Oceania at the close of the Meeting of the British Association in Australia in 1914.

From Section H.

That this Association co-operate with the Royal Anthropological Institute in urging upon His Majesty's Government the desirability of instituting an Imperial Bureau of Anthropology, and that the General Officers be empowered to take such action as may be necessary for this purpose.

From Section I.

With reference to Dr. A. D. Waller's paper on the Claim of Sir Charles Bell to the Anatomical Distinction of Motor and Sensory Nerves:—

1. The author of this paper has called the attention of the Sectional Committee to the fact that his communication conveys a serious charge relating to the republication by Bell in 1824 and subsequently of papers originally published in the 'Phil. Trans.' of the Royal Society in 1821.
2. In view of the importance attaching to the real authorship of the discovery of the distinction between motor and sensory nerves we have examined the printed documents quoted at pp. 298, 299, and verified the accuracy of the quotations given by Dr. Waller of the original passages of 1821 and of the republished passages of 1824.
3. In our opinion it will be necessary to reconsider carefully the claim first put forward by Bell in 1824 to the discovery of the distinction between motor and sensory nerves.
4. Dr. Waller's paper on the subject contains sufficient grounds for the revision of the conclusion published in the Report of the British Association for 1833, and we recommend that it be published *in extenso* in the Report of the present year.
5. In view of the importance of the historical claim of Bell we recommend that a committee be appointed to consider the case fully and report upon it.
6. In spite of the fact that many years have elapsed since November 12th, 1824, we are of opinion that a formal communication should be made to the Royal Society calling its attention to the existence of a spurious version of papers received by the Royal Society and published on its authority on July 12th, 1821.
7. The Sectional Committee recommends that the text of the foregoing resolutions be printed as an appendix to Dr. Waller's paper.

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[1] Subsequently withdrawn, having been previously printed elsewhere.

From the Committee of Recommendations.

That the Council be requested to consider the present practice of reckoning unspent balances of grants as part of the funds available for redistribution, and to report if any alteration in the practice is advisable.

Recommendations referred to the Council for consideration, and, if desirable, for action.

That the following Committees be authorised to receive contributions from sources other than the Association:—

'To aid investigators . . . to carry on . . . work at the Zoological Station at Naples.' (Section D.)

'To conduct Explorations with a view to ascertaining the Age of Stone Circles.' (Section H.)

'To investigate the Physical Characters of the Ancient Egyptians.' (Section H.)

Synopsis of Grants of Money appropriated for Scientific Purposes by the General Committee at the Portsmouth Meeting, September 1911. *The Names of Members entitled to call on the General Treasurer for the Grants are prefixed.*

Mathematical and Physical Science.

	£	*s.*	*d.*
*Turner, Professor H. H.—Seismological Observations	60	0	0
*Preece, Sir W. H.—Magnetic Observations at Falmouth	25	0	0
*Gill, Sir David—Establishing a Solar Observatory in Australia	50	0	0
*Shaw, Dr. W. N.—Upper Atmosphere	30	0	0
*Ramsay, Sir W.—Grant to the International Commission on Physical and Chemical Constants	30	0	0
*Hill, Professor M. J. M.—Further Tabulation of Bessel and other Functions	15	0	0

Chemistry.

	£	*s.*	*d.*
*Divers, Professor E.—Study of Hydro-aromatic Substances	20	0	0
*Armstrong, Professor H. E.—Dynamic Isomerism	30	0	0
*Kipping, Professor F. S.—Transformation of Aromatic Nitroamines	10	0	0
*Kipping, Professor F. S.—Electroanalysis	10	0	0
Hall, A. D.—Study of Plant Enzymes	30	0	0

Geology.

	£	*s.*	*d.*
*Tiddeman, R. H.—Erratic Blocks	5	0	0
*Lapworth, Professor C.—Palæozoic Rocks of Wales and the West of England	10	0	0
*Watts, Professor W. W.—Composition of Charnwood Rocks	2	0	0
*Watts, Professor W. W.—Igneous and Associated Sedimentary Rocks of Glensaul	15	0	0
Kendall, Professor P. F.—List of Characteristic Fossils	5	0	0
Lankester, Sir E. Ray.—Sutton Bone Bed	15	0	0
Hughes, Professor T. McK.—Bembridge Limestone at Creechbarrow Hill	20	0	0

Zoology.

	£	*s.*	*d.*
*Hickson, Professor S. J.—Table at the Zoological Station at Naples	30	0	0
*Woodward, Dr. H.—Index Animalium	75	0	0
*Shipley, Dr. A. E.—Belmullet Whaling Station	20	0	0
Bourne, Professor G. C.—Secondary Sexual Characters in Birds	10	0	0
Carried forward	£517	0	0

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* Reappointed.

	£	s.	d.
Brought forward	517	0	0

Geography.

*Herbertson, Professor A. J.—Equal Area Maps	20	0	0
Close, Col. C. F.—Calculation of Areas on the Spheroid	25	0	0

Engineering.

*Preece, Sir W. H.—Gaseous Explosions	60	0	0

Anthropology.

*Munro, Dr. R.—Lake Villages in the neighbourhood of Glastonbury	5	0	0
*Read, C. H.—Age of Stone Circles	15	0	0
*Read, C. H.—Anthropological Notes and Queries	40	0	0
*Munro, Dr. R.—Artificial Islands in Highland Lochs	13	0	0
Smith, Professor G. Elliot.—Physical Characters of the Ancient Egyptians	40	0	0
Haddon, Dr. A. C.—Excavations in Easter Island	15	0	0
*Thompson, Professor A.—Anthropometric Investigations in the British Isles	5	0	0

Physiology.

*Schafer, Professor E. A.—The Ductless Glands	35	0	0
*Hickson, Professor S. J.—Table at the Zoological Station at Naples	20	0	0
*Waller, Dr. A. D.—Anæsthetics	20	0	0
Macdonald, Professor J. S.—Calorimetric Observations	40	0	0

Botany.

*Scott, Dr. D. H.—Structure of Fossil Plants	15	0	0
*Darwin, Dr. F.—Experimental Study of Heredity	35	0	0
*Johnson, Professor T.—Survey of Clare Island	20	0	0
Seward, Professor A. C.—Jurassic Flora of Yorkshire	20	0	0

Education.

*Findlay, Professor J. J.—Mental and Physical Factors involved in Education	5	0	0
*Miers, Principal H. A.—Overlapping between Secondary and Higher Education	5	0	0
*Eggar, W. D.—Industrial and Poor Law Schools	10	0	0
Auden, Dr. G. A.—Influence of School Books on Eyesight	5	0	0
Carried forward	£985	0	0

Reappointed.

	£	s.	d.
Brought forward	985	0	0
Corresponding Societies Committee.			
*Whitaker, W.—For Preparation of Report	25	0	0
Special Grant.			
Read, Clement.—Collections to illustrate Natural History, &c., of the Isle of Wight	40	0	0
Total	£1,050	0	0

* Reappointed.

Annual Meetings, 1912, 1913, *and* 1914.

The Annual Meeting of the Association in 1912 will be held at Dundee, commencing September 4; in 1913, at Birmingham; and in 1914, in Australia.

PRESIDENT'S ADDRESS.

ADDRESS

BY

PROFESSOR SIR WILLIAM RAMSAY, K.C.B., PH.D., LL.D., D.SC., M.D., F.R.S.,

PRESIDENT.

It is now eighty years since this Association first met at York, under the presidency of Earl Fitzwilliam. The object of the Association was then explicitly stated: 'To give a stronger impulse and a more systematic direction to scientific inquiry, to promote the intercourse of those who cultivate science in different parts of the British Empire with one another and with foreign philosophers, to obtain a more general attention to the objects of science and a removal of any disadvantages of a public kind which impede its progress.'

In 1831 the workers in the domain of science were relatively few. The Royal Society, which was founded by Dr. Willis, Dr. Wilkins, and others, under the name of the 'Invisible, or Philosophical College,' about the year 1645, and which was incorporated in December 1660, with the approval of King Charles II., was almost the only meeting-place for those interested in the progress of science; and its Philosophical Transactions, begun in March 1664-65, almost the only medium of publication. Its character was described in the following words of a contemporary poem:—

'This noble learned Corporation
  Not for themselves are thus combined
To prove all things by demonstration
But for the public good of the nation,
  And general benefit of mankind.'

The first to hive off from the Royal Society was the Linnean Society for the promotion of botanical studies, founded in 1788 by Sir James Edward Smith, Sir Joseph Banks, and other Fellows of the Royal Society; in 1807 it was followed by the Geological Society; at a later date the Society of Antiquaries, the Chemical, the Zoological, the Physical, the Mathematical, and many other societies were founded.

And it was felt by those capable of forming a judgment that, as well expressed by Lord Playfair at Aberdeen in 1885, 'Human progress is so identified with scientific thought, both in its conception and realisation, that it seems as if they were alternative terms in the history of civilisation.' This is only an echo through the ages of an utterance of the great Englishman, Roger Bacon, who wrote in 1250 A.D.: 'Experimental science has three great prerogatives over all other sciences: it verifies conclusions by direct experiment; it discovers truths which they could never reach; and it investigates the secrets of Nature and opens to us a knowledge of the past and of the future.'

The world has greatly changed since 1831; the spread of railways and the equipment of numerous lines of steamships have contributed to the peopling of countries at that time practically uninhabited. Moreover, not merely has travelling been made almost infinitely easier, but communication by post has been enormously expedited and cheapened; and the telegraph, the telephone, and wireless telegraphy have simplified as well as complicated human existence. Furthermore, the art of engineering has made such strides that the question 'Can it be done?' hardly arises, but rather 'Will it pay to do it?' In a word, the human race has been familiarised with the applications of science; and men are ready to believe almost anything, if brought forward in its name.

Education, too, in the rudiments of science has been introduced into almost all schools; young children are taught the elements of physics and chemistry. The institution of a Section for Education in our Association (L) has had for its object the organising of such instruction, and much useful advice has been proffered. The problem is, indeed, largely an educational one; it is being solved abroad in various ways—in Germany and in most European States by elaborate Governmental schemes dealing with elementary and advanced instruction, literary, scientific, and technical; and in the United States and in Canada by the far-sightedness of the people: both employers and employees recognise the value of training and of originality, and on both sides sacrifices are made to ensure efficiency.

In England we have made technical education a local, not an Imperial question; instead of half a dozen first-rate institutions of University rank we have a hundred, in which the institutions are necessarily understaffed, in which the staffs are mostly overworked and underpaid; and the training given is that not for captains of industry but for workmen and foremen. 'Efficient captains cannot be replaced by a large number of fairly good corporals.' Moreover, to induce scholars to enter these institutions, they are bribed by scholarships, a form of pauperisation practically unknown in every country but our own; and to crown the edifice, we test results by examinations of a

kind not adapted to gauge originality and character (if, indeed, these can ever be tested by examination), instead of, as on the Continent and in America, trusting the teachers to form an honest estimate of the capacity and ability of each student, and awarding honours accordingly.

The remedy lies in our own hands. Let me suggest that we exact from all gainers of University scholarships an undertaking that, if and when circumstances permit, they will repay the sum which they have received as a scholarship, bursary, or fellowship. It would then be possible for an insurance company to advance a sum representing the capital value, viz., 7,464,931*l.*, of the scholarships, reserving, say, 20 per cent. for non-payment, the result of mishap or death. In this way a sum of over six million pounds, of which the interest is now expended on scholarships, would be available for University purposes. This is about one-fourth of the sum of twenty-four millions stated by Sir Norman Lockyer at the Southport meeting as necessary to place our University education on a satisfactory basis. A large part of the income of this sum should be spent in increasing the emoluments of the chairs; for, unless the income of a professor is made in some degree commensurate with the earnings of a professional man who has succeeded in his profession, it is idle to suppose that the best brains will be attracted to the teaching profession. And it follows that unless the teachers occupy the first rank, the pupils will not be stimulated as they ought to be.

Again, having made the profession of a teacher so lucrative as to tempt the best intellects in the country to enter it, it is clear that such men are alone capable of testing their pupils. The modern system of 'external examinations,' known only in this country, and answerable for much of its lethargy, would disappear; schools of thought would arise in all subjects, and the intellectual as well as the industrial prosperity of our nation would be assured. As things are, can we wonder that as a nation we are not scientific? Let me recommend those of my hearers who are interested in the matter to read a recent report on Technical Education by the Science Guild.

I venture to think that, in spite of the remarkable progress of science and of its applications, there never was a time when missionary effort was more needed. Although most people have some knowledge of the results of scientific inquiry, few, very few, have entered into its spirit. We all live in hope that the world will grow better as the years roll on. Are we taking steps to secure the improvement of the race? I plead for recognition of the fact that progress in science does not only consist in accumulating information which may be put to practical use, but in developing a spirit of prevision, in taking thought for the morrow; in attempting to forecast the future, not by vague surmise but by

orderly marshalling of facts, and by deducing from them their logical outcome; and chiefly in endeavouring to control conditions which may be utilised for the lasting good of our people. We must cultivate a belief in the 'application of trained intelligence to all forms of national activity.'

The Council of the Association has had under consideration the formation of a Section of Agriculture. For some years this important branch of applied science, borrowing as it does from botany, from physics, from chemistry, and from economics, has in turn enjoyed the hospitality of each of these Sections, itself having been made a sub-section of one of these more definite sciences. It is proposed this year to form an Agricultural Section. Here there is need of missionary effort; for our visits to our colonies have convinced many of us that much more is being done for the farmer in the newer parts of the British Empire than at home. Agriculture is, indeed, applied botany, chemistry, entomology, and economics; and has as much right to independent treatment as has engineering, which may be strictly regarded as applied physics.

The question has often been debated whether the present method of conducting our proceedings is the one best adapted to gain our ends. We exist professedly 'to give a stronger impulse and a more systematic direction to scientific inquiry.' The Council has had under consideration various plans framed with the object of facilitating our work, and the result of its deliberations will be brought under your attention at a later date. To my mind, the greatest benefit bestowed on science by our meetings is the opportunity which they offer for friendly and unrestrained intercourse, not merely between those following different branches of science, but also with persons who, though not following science professionally, are interested in its problems. Our meetings also afford an opportunity for younger men to make the acquaintance of older men. I am afraid that we who are no longer in the spring of our lifetime, perhaps from modesty, perhaps through carelessness, often do not sufficiently realise how stimulating to a young worker a little sympathy can be; a few words of encouragement go a long way. I have in my mind words which encouraged me as a young man, words spoken by the leaders of Associations now long past—by Playfair, by Williamson, by Frankland, by Kelvin, by Stokes, by Francis Galton, by Fitzgerald, and many others. Let me suggest to my older scientific colleagues that they should not let such pleasant opportunities slip.

Since our last meeting the Association has to mourn the loss by death of many distinguished members. Among these are:—

Dr. John Beddoe, who served on the Council from 1870 to 1875, has recently died at a ripe old age, after having achieved a world-wide reputation by his magnificent work in the domain of anthropology.

Sir Rubert Boyce, called away at a comparatively early age in the middle of his work, was for long a colleague of mine at University College, and was one of the staff of the Royal Commission on Sewage Disposal. The service he rendered science in combating tropical diseases is well known.

Sir Francis Galton died at the beginning of the year, at the advanced age of 89. His influence on science has been characterised by Professor Karl Pearson in his having maintained the idea that exact quantitative methods could—nay, must—be applied to many branches of science which had been held to be beyond the field of either mathematical or physical treatment. Sir Francis was General Secretary of this Association from 1863 to 1868; he was President of Section E in 1862, and again in 1872; he was President of Section H in 1885; but, although often asked to accept the office of President of the Association, his consent could never be obtained. Galton's name will always be associated with that of his friend and relative, Charles Darwin, as one of the most eminent and influential of English men of science.

Professor Thomas Rupert Jones, also, like Galton, a member of this Association since 1860, and in 1891 President of the Geological Section, died in April last at the advanced age of 91. Like Dr. Beddoe, he was a medical man with wide scientific interests. He became a distinguished geologist, and for many years edited the Quarterly Journal of the Geological Society.

Professor Story Maskelyne, at one time a diligent frequenter of our meetings, and a member of the Council from 1874 to 1880, was a celebrated mineralogist and crystallographer. He died at the age of 88. The work which he did in the University of Oxford and at the British Museum is well known. In his later life he entered Parliament.

Dr. Johnstone Stoney, President of Section A in 1897, died on July 1, in his eighty-sixth year. He was one of the originators of the modern view of the nature of electricity, having given the name 'electron' to its unit as far back as 1874. His investigations dealt with spectroscopy and allied subjects, and his philosophic mind led him to publish a scheme of ontology which, I venture to think, must be acknowledged to be the most important work which has ever been done on that difficult subject.

Among our corresponding members we have lost Professor Bohr, of Copenhagen; Professor Brühl, of Heidelberg; Hofrat Dr. Caro, of Berlin; Professor Fittig, of Strassburg; and Professor Van't Hoff, of Berlin. I cannot omit to mention that veteran of science, Professor Cannizzaro, of Rome, whose work in the middle of last century placed chemical science on the firm basis which it now occupies.

I knew all these men, some of them intimately; and, if I have not

ventured on remarks as to their personal qualities, it is because it may be said of all of them that they fought a good fight and maintained the faith that only by patient and unceasing scientific work is human progress to be hoped for.

It has been the usual custom of my predecessors in office either to give a summary of the progress of science within the past year or to attempt to present in intelligible language some aspect of the science in which they have themselves been engaged. I possess no qualifications for the former course, and I therefore ask you to bear with me while I devote some minutes to the consideration of ancient and modern views regarding the chemical elements. To many in my audience part of my story will prove an oft-told tale; but I must ask those to excuse me, in order that it may be in some wise complete.

In the days of the early Greeks the word 'element' was applied rather to denote a property of matter than one of its constituents. Thus, when a substance was said to contain fire, air, water, and earth (of which terms a childish game doubtless once played by all of us is a relic), it probably meant that they partook of the nature of the so-called elements. Inflammability showed the presence of concealed fire; the escape of 'airs' when some substances are heated or when vegetable or animal matter is distilled no doubt led to the idea that these airs were imprisoned in the matters from which they escaped; hardness and permanence were ascribed to the presence of earth, while liquidity and fusibility were properties conveyed by the presence of concealed water. At a later date the 'Spagyrics' added three 'hypostatical principles' to the quadrilateral; these were 'salt, 'sulphur,' and 'mercury.' The first conveyed solubility, and fixedness in fire; the second, inflammability; and the third, the power which some substances manifest of producing a liquid, generally termed 'phlegm,' on application of heat, or of themselves being converted into the liquid state by fusion.

It was Robert Boyle, in his 'Skeptical Chymist,' who first controverted these ancient and mediæval notions, and who gave to the word 'element' the meaning that it now possesses—the constituent of a compound. But in the middle of the seventeenth century chemistry had not advanced far enough to make his definition useful; for he was unable to suggest any particular substance as elementary. And, indeed, the main tenet of the doctrine of 'phlogiston,' promulgated by Stahl in the eighteenth century, and widely accepted, was that all bodies capable of burning or of being converted into a 'calx,' or earthly powder, did so in virtue of the escape of a subtle fluid from their pores; this fluid could be restored to the 'calces' by heating them with other substances rich in phlogiston, such as charcoal, oil, flour, and the like. Stahl, however false his theory, had at least the merit of having

constructed a reversible chemical equation: Metal—phlogiston = Calx; Calx + phlogiston = Metal.

It is difficult to say when the first element was known to be an element. After Lavoisier's overthrow of the phlogistic hypothesis, the part played by oxygen, then recently discovered by Priestley and Scheele, came prominently forward. Loss of phlogiston was identified with oxidation; gain of phlogiston, with loss of oxygen. The scheme of nomenclature (Méthode de Nomenclature chimique') published by Lavoisier in conjunction with Guyton de Morveau, Berthollet, and Fourcroy, created a system of chemistry out of a wilderness of isolated facts and descriptions. Shortly after, in 1789, Lavoisier published his 'Traité de Chimie,' and in the preface the words occur: 'If we mean by "elements" the simple and indivisible molecules of which bodies consist, it is probable that we do not know them; if, on the other hand, we mean the last term in analysis, then every substance which we have not been able to decompose is for us an element; not that we can be certain that bodies which we regard as simple are not themselves composed of two or even a larger number of elements, but because these elements can never be separated, or rather, because we have no means of separating them, they act, so far as we can judge, as elements; and we cannot call them "simple" until experiment and observation shall have furnished a proof that they are so.'

The close connection between 'crocus of Mars' and metallic iron, the former named by Lavoisier 'oxyde de fer,' and similar relations between metals and their oxides, made it likely that bodies which reacted as oxides in dissolving in acids and forming salts must also possess a metallic substratum. In October 1807 Sir Humphry Davy proved the correctness of this view for soda and potash by his famous experiment of splitting these bodies by a powerful electric current into oxygen and hydrogen on the one hand, and the metals sodium and potassium on the other. Calcium, barium, strontium, and magnesium were added to the list as constituents of the oxides, lime, barytes, strontia, and magnesia. Some years later Scheele's 'dephlogisticated marine acid,' obtained by heating pyrolusite with 'spirit of salt,' was identified by Davy as in all likelihood elementary. His words are: 'All the conclusions which I have ventured to make respecting the undecompounded nature of oxymuriatic gas are, I conceive, entirely confirmed by these new facts.' 'It has been judged most proper to suggest a name founded upon one of its obvious and characteristic properties, its colour, and to call it chlorine.' The subsequent discovery of iodine by Courtois in 1812, and of bromine by Balard in 1826, led to the inevitable conclusion that fluorine, if isolated, should resemble the other halogens in properties, and much later, in the able hands of Moissan, this was shown to be true.

The modern conception of the elements was much strengthened by Dalton's revival of the Greek hypothesis of the atomic constitution of matter, and the assigning to each atom a definite weight. This momentous step for the progress of chemistry was taken in 1803; the first account of the theory was given to the public with Dalton's consent in the third edition of Thomas Thomson's 'System of Chemistry' in 1807; it was subsequently elaborated in the first volume of Dalton's own 'System of Chemical Philosophy,' published in 1808. The notion that compounds consisted of aggregations of atoms of elements, united in definite or multiple proportions, familiarised the world with the conception of elements as the bricks of which the Universe is built. Yet the more daring spirits of that day were not without hope that the elements themselves might prove decomposable. Davy, indeed, went so far as to write in 1811: 'It is the duty of the chemist to be bold in pursuit; he must recollect how contrary knowledge is to what appears to be experience. . . . To inquire whether the elements be capable of being composed and decomposed is a grand object of true philosophy.' And Faraday, his great pupil and successor, at a later date, 1815, was not behind Davy in his aspirations, when he wrote: 'To decompose the metals, to re-form them, and to realise the once absurd notion of transformation—these are the problems now given to the chemist for solution.'

Indeed, the ancient idea of the unitary nature of matter was in those days held to be highly probable. For attempts were soon made to demonstrate that the atomic weights were themselves multiples of that of one of the elements. At first the suggestion was that oxygen was the common basis; and later, when this supposition turned out to be untenable, the claims of hydrogen were brought forward by Prout. The hypothesis was revived in 1842 when Liebig and Redtenbacher, and subsequently Dumas, carried out a revision of the atomic weights of some of the commoner elements, and showed that Berzelius was in error in attributing to carbon the atomic weight 12.25, instead of 12.00. Of recent years a great advance in the accuracy of the determinations of atomic weights has been made, chiefly owing to the work of Richards and his pupils, of Gray, and of Guye and his collaborators, and every year an international committee publishes a table in which the most probable numbers are given on the basis of the atomic weight of oxygen being taken as sixteen. In the table for 1911, of eighty-one elements no fewer than forty-three have recorded atomic weights within one-tenth of a unit above or below an integral number. My mathematical colleague, Karl Pearson, assures me that the probability against such a condition being fortuitous is 20,000 millions to one.

The relation between the elements has, however, been approached from another point of view. After some preliminary suggestions by

Döbereiner, Dumas, and others, John Newlands in 1862 and the following years arranged the elements in the numerical order of their atomic weights, and published in the 'Chemical News' of 1863 what he termed his law of octaves—that every eighth element, like the octave of a musical note, is in some measure a repetition of its forerunner. Thus, just as C on the third space is the octave of C below the line, so potassium, in 1863 the eighth known element numerically above sodium, repeats the characters of sodium, not only in its physical properties—colour, softness, ductility, malleability, &c.—but also in the properties of its compounds, which, indeed, resemble each other very closely. The same fundamental notion was reproduced at a later date and independently by Lothar Meyer and Dmitri Mendeléeff; and to accentuate the recurrence of such similar elements in *periods*, the expression 'the periodic system of arranging the elements' was applied to Newlands' arrangement in octaves. As everyone knows, by help of this arrangement Mendeléeff predicted the existence of then unknown elements, under the names of eka-boron, eka-aluminium, and eka-silicon, since named *scandium*, *gallium*, and *germanium* by their discoverers, Cleve, Lecoq de Boisbaudran, and Winckler.

It might have been supposed that our knowledge of the elements was practically complete; that perhaps a few more might be discovered to fill the outstanding gaps in the periodic table. True, a puzzle existed and still exists in the classification of the 'rare earths,' oxides of metals occurring in certain minerals; these metals have atomic weights between 139 and 180, and their properties preclude their arrangement in the columns of the periodic table. Besides these, the discovery of the inert gases of the atmosphere, of the existence of which Johnstone Stoney's spiral curve, published in 1888, pointed a forecast, joined the elements like sodium and potassium, strongly electro-negative, to those like fluorine and chlorine, highly electro-positive, by a series of bodies electrically as well as chemically inert, and neon, argon, krypton, and xenon formed links between fluorine and sodium, chlorine and potassium, bromine and rubidium, and iodine and cæsium.

Including the inactive gases, and adding the more recently discovered elements of the rare earths, and radium, of which I shall have more to say presently, there are eighty-four definite elements, all of which find places in the periodic table, if merely numerical values be considered. Between lanthanum, with atomic weight 139, and tantalum, 181, there are in the periodic table seventeen spaces; and although it is impossible to admit, on account of their properties, that the elements of the rare earths can be distributed in successive columns (for they all resemble lanthanum in properties), yet there are now fourteen such elements; and it is not improbable that other three will be separated from the complex mixture of their oxides by further work.

Assuming that the metals of the rare earths fill these seventeen spaces, how many still remain to be filled? We will take for granted that the atomic weight of uranium, 238.5, which is the highest known, forms an upper limit not likely to be surpassed. It is easy to count the gaps; there are eleven.

But we are confronted by an *embarras de richesse*. The discovery of radioactivity by Henri Becquerel, of radium by the Curies, and the theory of the disintegration of the radioactive elements, which we owe to Rutherford and Soddy, have indicated the existence of no fewer than twenty-six elements hitherto unknown. To what places in the periodic table can they be assigned?

But what proof have we that these substances are elementary? Let us take them in order.

Beginning with radium, its salts were first studied by Madame Curie; they closely resemble those of barium—sulphate, carbonate, and chromate insoluble; chloride and bromide similar in crystalline form to chloride and bromide of barium; metal, recently prepared by Madame Curie, white, attacked by water, and evidently of the type of barium. The atomic weight, too, falls into its place; as determined by Madame Curie and by Thorpe, it is 89.5 units higher than that of barium; in short, there can be no doubt that radium fits the periodic table, with an atomic weight of about 226.5. It is an undoubted element.

But it is a very curious one. For it is *unstable*. Now, stability was believed to be the essential characteristic of an element. Radium, however, disintegrates—that is, changes into other bodies, and at a constant rate. If a gram of radium is kept for 1,760 years, only half a gram will be left at the end of that time; half of it will have given other products. What are they? We can answer that question. Rutherford and Soddy found that it gives a condensable gas, which they named 'radium-emanation'; and Soddy and myself, in 1903, discovered that, in addition, it evolves helium, one of the inactive series of gases, like argon. Helium is an undoubted element, with a well-defined spectrum; it belongs to a well-defined series. And radium-emanation, which was shown by Rutherford and Soddy to be incapable of chemical union, has been liquefied and solidified in the laboratory of University College, London; its spectrum has been measured and its density determined. From the density the atomic weight can be calculated, and it corresponds to that of a congener of argon, the whole series being: helium, 4; neon, 20; argon, 40; krypton, 83; xenon, 130; unknown, about 178; and niton (the name proposed for the emanation to recall its connection with its congeners, and its phosphorescent properties), about 222.4. The formation of niton from radium would therefore be represented by the equation: radium (226.4) = helium (4) + niton (222.4).

Niton, in its turn, disintegrates, or decomposes, and at a rate much more rapid than the rate of radium; half of it has changed in about four days. Its investigation, therefore, had to be carried out very rapidly, in order that its decomposition might not be appreciable while its properties were being determined. Its product of change was named by Rutherford 'radium A,' and it is undoubtedly deposited from niton as a metal, with simultaneous evolution of helium; the equation would therefore be: niton (222.4) = helium (4) + radium A (218.4). But it is impossible to investigate radium A chemically, for in three minutes it has half changed into another solid substance, radium B, again giving off helium. This change would be represented by the equation: radium A (218.4) = helium (4) + radium B (214.4). Radium B, again, can hardly be examined chemically, for in twenty-seven minutes it has half changed into radium C^1. In this case, however, no helium is evolved; only atoms of negative electricity, to which the name 'electrons' has been given by Dr. Stoney, and these have minute weight which, although approximately ascertainable, at present has defied direct measurement. Radium C^1 has a half-life of 19.5 minutes; too short, again, for chemical investigation; but it changes into radium C^2, and in doing so each atom parts with a helium atom; hence the equation: radium C^1 (214.4) = helium (4) + radium C^2 (210.4). In 2.5 minutes, radium C^2 is half gone, parting with electrons, forming radium D.

Radium D gives the chemist a chance, for its half-life is no less than sixteen and a half years. Without parting with anything detectable, radium D passes into radium E, of which the half-life period is five days; and lastly radium E changes spontaneously into radium F, the substance to which Madame Curie gave the name 'polonium' in allusion to her native country, Poland. Polonium, in its turn, is half changed in 140 days with loss of an atom of helium into an unknown metal, supposed to be possibly lead. If that be the case, the equation would run: polonium (210.4) = helium (4) + lead (206.4). But the atomic weight of lead is 207.1, and not 206.4; however, it is possible that the atomic weight of radium is 227.1, and not 226.4.

We have another method of approaching the same subject. It is practically certain that the progenitor of radium is uranium; and that the transformation of uranium into radium involves the loss of three alpha particles; that is, of three atoms of helium. The atomic weight of helium may be taken as one of the most certain; it is 3.994, as determined by Mr. Watson, in my laboratories. Three atoms would therefore weigh 11.98, practically 12. There is, however, still some uncertainty in the atomic weight of uranium; Richards and Merigold make it 239.4; but the general mean, calculated by Clarke, is 239.0. Subtracting 12 from these numbers, we have the values 227.0, and

227.4 for the atomic weight of radium. It is as yet impossible to draw any certain conclusion.

The importance of the work which will enable a definite and sure conclusion to be drawn is this: For the first time, we have accurate knowledge as to the descent of some of the elements. Supposing the atomic weight of uranium to be certainly 239, it may be taken as proved that in losing three atoms of helium, radium is produced, and, if the change consists solely in the loss of the three atoms of helium, the atomic weight of radium must necessarily be 227. But it is known that β-rays, or electrons, are also parted with during this change; and electrons have weight. How many electrons are lost is unknown; therefore, although the weight of an electron is approximately known, it is impossible to say how much to allow for in estimating the atomic weight of radium. But it is possible to solve this question indirectly, by determining exactly the atomic weights of radium and of uranium; the difference between the atomic weight of radium *plus* 12, *i.e.*, plus the weight of three atoms of helium, and that of uranium, will give the weight of the number of electrons which escape. Taking the most probable numbers available, viz., 239.4 for uranium, and 226.8 for radium, and adding 12 to the latter, the weight of the escaping electrons would be 0.6.

The correct solution of this problem would in great measure clear up the mystery of the irregularities in the periodic table, and would account for the deviations from Prout's Law, that the atomic weights are multiples of some common factor or factors. I also venture to suggest that it would throw light on allotropy, which in some cases at least may very well be due to the loss or gain of electrons, accompanied by a positive or negative heat-change. Incidentally, this suggestion would afford places in the periodic table for the somewhat overwhelming number of pseudo-elements the existence of which is made practically certain by the disintegration hypothesis. Of the twenty-six elements derived from uranium, thorium, and actinium, ten, which are formed by the emission of electrons alone, may be regarded as allotropes or pseudo-elements; this leaves sixteen, for which sixteen or seventeen gaps would appear to be available in the periodic table, provided the reasonable supposition be made that a second change in the length of the periods has taken place. It is above all things certain that it would be a fatal mistake to regard the existence of such elements as irreconcilable with the periodic arrangement, which has rendered to systematic chemistry such signal service in the past.

Attention has repeatedly been drawn to the enormous quantity of energy stored up in radium and its descendants. That in its emanation, niton, is such that if what it parts with as heat during its disintegration

were available, it would be equal to three and a half million times the energy available by the explosion of an equal volume of detonating gas—a mixture of one volume of oxygen with two volumes of hydrogen. The major part of this energy comes, apparently, from the expulsion of particles (that is, of atoms of helium) with enormous velocity. It is easy to convey an idea of this magnitude in a form more realisable, by giving it a somewhat mechanical turn. Suppose that the energy in a ton of radium could be utilised in thirty years, instead of being evolved at its invariable slow rate of 1760 years for half-disintegration, it would suffice to propel a ship of 15,000 tons, with engines of 15,000 horse-power, at the rate of 15 knots an hour, for 30 years—practically the lifetime of the ship. To do this actually requires a million and a half tons of coal.

It is easily seen that the virtue of the energy of the radium consists in the small weight in which it is contained; in other words, the radium-energy is in an enormously concentrated form. I have attempted to apply the energy contained in niton to various purposes; it decomposes water, ammonia, hydrogen chloride, and carbon dioxide, each into its constituents; further experiments on its action on salts of copper appeared to show that the metal copper was converted partially into lithium, a metal of the sodium column; and similar experiments, of which there is not time to speak, indicate that thorium, zirconium, titanium, and silicon are degraded into carbon; for solutions of compounds of these, mixed with niton, invariably generated carbon dioxide; while cerium, silver, mercury, and some other metals gave none. One can imagine the very atoms themselves, exposed to bombardment by enormously quickly moving helium atoms, failing to withstand the impacts. Indeed, the argument *à priori* is a strong one; if we know for certain that radium and its descendants decompose spontaneously, evolving energy, why should not other more stable elements decompose when subjected to enormous strains?

This leads to the speculation whether, if elements are capable of disintegration, the world may not have at its disposal a hitherto unsuspected source of energy. If radium were to evolve its stored-up energy at the same rate that gun-cotton does, we should have an undreamt-of explosive; could we control the rate we should have a useful and potent source of energy, provided always that a sufficient supply of radium were forthcoming. But the supply is certainly a very limited one; and it can be safely affirmed that the production will never surpass half an ounce a year. If, however, the elements which we have been used to consider as permanent are capable of changing with evolution of energy; if some form of catalyser could be discovered which would usefully increase their almost inconceivably slow rate of change,

then it is not too much to say that the whole future of our race would be altered.

The whole progress of the human race has indeed been due to individual members discovering means of concentrating energy, and of transforming one form into another. The carnivorous animals strike with their paws and crush with their teeth; the first man who aided his arm with a stick in striking a blow discovered how to concentrate his small supply of kinetic energy; the first man who used a spear found that its sharp point in motion represented a still more concentrated form; the arrow was a further advance, for the spear was then propelled by mechanical means; the bolt of the crossbow, the bullet shot forth by compressed hot gas, first derived from black powder, later, from high explosives; all these represent progress. To take another sequence: the preparation of oxygen by Priestley applied energy to oxide of mercury in the form of heat; Davy improved on this when he concentrated electrical energy into the tip of a thin wire by aid of a powerful battery, and isolated potassium and sodium.

Great progress has been made during the past century in effecting the conversion of one form of energy into others, with as little useless expenditure as possible. Let me illustrate by examples: A good steam engine converts about one-eighth of the potential energy of the fuel into useful work; seven-eighths are lost as unused heat, and useless friction. A good gas-engine utilises more than one-third of the total energy in the gaseous fuel; two-thirds are uneconomically expended. This is a universal proposition; in order to effect the conversion from one form of energy into another, some energy must be expended uneconomically. If A is the total energy which it is required to convert; if B is the energy into which it is desired to convert A; then a certain amount of energy, C, must be expended to effect the conversion. In short, $A = B + C$. It is eminently desirable to keep C, the useless expenditure, as small as possible; it can never equal zero, but it can be made small. The ratio of C to B (the economic coefficient) should therefore be as large as is attainable.

The middle of the nineteenth century will always be noted as the beginning of the golden age of science; the epoch when great generalisations were made, of the highest importance on all sides, philosophical, economic, and scientific. Carnot, Clausius, Helmholtz, Julius Robert Mayer abroad, and the Thomsons, Lord Kelvin and his brother James, Rankine, Tait, Joule, Clerk Maxwell, and many others at home, laid the foundations on which the splendid structure has been erected. That the latent energy of fuel can be converted into energy of motion by means of the steam engine is what we owe to Newcomen and Watt; that the kinetic energy of the fly-wheel can be transformed into electrical energy was due to Faraday, and to him, too, we are indebted

for the re-conversion of electrical energy into mechanical work; and it is this power of work which gives us leisure, and which enables a small country like ours to support the population which inhabits it.

I suppose that it will be generally granted that the Commonwealth of Athens attained a high-water mark in literature and thought, which has never yet been surpassed. The reason is not difficult to find; a large proportion of its people had ample leisure, due to ample means; they had time to think, and time to discuss what they thought. How was this achieved? The answer is simple: each Greek Freeman had on an average at least five helots who did his bidding, who worked his mines, looked after his farm, and, in short, saved him from manual labour. Now, we in Britain are much better off; the population of the British Isles is in round numbers 45 millions; there are consumed in our factories at least 50 million tons of coal annually, and 'it is generally agreed that the consumption of coal per indicated horse-power per hour is on an average about 5 lb.' (Royal Commission on Coal Supplies, Part I.). This gives seven million horse-power per year. How many man-power are equal to a horse-power? I have arrived at an estimate thus: a Bhutanese can carry 230 lb. *plus* his own weight, in all 400 lb., up a hill 4,000 feet high in eight hours; this is equivalent to about one-twenty-fifth of a horse-power; seven million horse-power are therefore about 175 million man-power. Taking a family as consisting on the average of five persons, our 45 millions would represent nine million families; and dividing the total man-power by the number of families, we must conclude that each British family has, on the average, nearly twenty 'helots' doing his bidding, instead of the five of the Athenian family. We do not appear, however, to have gained more leisure thereby, but it is this that makes it possible for the British Isles to support the population which it does.

We have in this world of ours only a limited supply of stored-up energy; in the British Isles a very limited one—namely, our coalfields. The rate at which this supply is being exhausted has been increasing very steadily for the last forty years, as anyone can prove by mapping the data given on page 27, table D, of the General Report of the Royal Commission on Coal Supplies (1906). In 1870, 110 million tons were mined in Great Britain, and ever since the amount has increased by three and a third million tons a year. The available quantity of coal in the proved coalfields is very nearly 100,000 million tons; it is easy to calculate that if the rate of working increases as it is doing our coal will be completely exhausted in 175 years. But, it will be replied, the rate of increase will slow down. Why? It has shown no sign whatever of slackening during the last forty years. Later, of course, it must slow down, when coal grows dearer owing to approaching exhaustion. It may also be said that 175 years is a long time; why, I myself have

seen a man whose father fought in the '45 on the Pretender's side, nearly 170 years ago! In the life of a nation 175 years is a span.

This consumption is still proceeding at an accelerated rate. Between 1905 and 1907 the amount of coal raised in the United Kingdom increased from 236 to 268 million tons, equal to six tons per head of the population, against three and a half tons in Belgium, two and a half tons in Germany, and one ton in France. Our commercial supremacy and our power of competing with other European nations are obviously governed, so far as we can see, by the relative price of coal; and when our prices rise, owing to the approaching exhaustion of our supplies, we may look forward to the near approach of famine and misery.

Having been struck some years ago with the optimism of my non-scientific friends as regards our future, I suggested that a committee of the British Science Guild should be formed to investigate our available sources of energy. This Guild is an organisation founded by Sir Norman Lockyer, after his tenure of the Presidency of this Association, for the purpose of endeavouring to impress on our people and their Government the necessity of viewing problems affecting the race and the State from the standpoint of science; and the definition of science in this, as in other connections, is simply the acquisition of knowledge, and orderly reasoning on experience already gained and on experiments capable of being carried out, so as to forecast and control the course of events; and, if possible, to apply this knowledge to the benefit of the human race.

The Science Guild has enlisted the services of a number of men, each eminent in his own department, and each has now reported on the particular source of energy of which he has special knowledge.

Besides considering the uses of coal and its products, and how they may be more economically employed, in which branches the Hon. Sir Charles Parsons, Mr. Dugald Clerk, Sir Boverton Redwood, Dr. Beilby, Dr. Hele-Shaw, Prof. Vivian Lewes and others have furnished reports, the following sources of energy have been brought under review: The possibility of utilising the tides; the internal heat of the earth; the winds; solar heat; water-power; the extension of forests, and the use of wood and peat as fuels; and lastly, the possibility of controlling the undoubted but almost infinitely slow disintegration of the elements, with the view of utilising their stored-up energy.

However interesting a detailed discussion of these possible sources of energy might be, time prevents my dwelling on them. Suffice it to say that the Hon. R. J. Strutt has shown that in this country at least it would be impracticable to attempt to utilise terrestrial heat from bore-holes; others have deduced that from the tides, the winds, and water-power small supplies of energy are no doubt obtainable, but that, in

comparison with that derived from the combustion of coal, they are negligible; nothing is to be hoped for from the direct utilisation of solar heat in this temperate and uncertain climate; and it would be folly to consider seriously a possible supply of energy in a conceivable acceleration of the liberation of energy by atomic change. It looks utterly improbable, too, that we shall ever be able to utilise the energy due to the revolution of the earth on her axis, or to her proper motion round the sun.

Attention should undoubtedly be paid to forestry, and to the utilisation of our stores of peat. On the Continent, the forests are largely the property of the State; it is unreasonable, especially in these latter days of uncertain tenure of property, to expect any private owner of land to invest money in schemes which would at best only benefit his descendants, but which, under our present trend of legislation, do not promise even that remote return. Our neighbours and rivals, Germany and France, spend annually 2,200,000*l.* on the conservation and utilisation of their forests; the net return is 6,000,000*l.* There is no doubt that we could imitate them with advantage. Moreover, an increase in our forests would bring with it an increase in our water-power; for without forest land rain rapidly reaches the sea, instead of distributing itself, so as to keep the supply of water regular, and so more easily utilised.

Various schemes have been proposed for utilising our deposits of peat: I believe that in Germany the peat industry is moderately profitable; but our humid climate does not lend itself to natural evaporation of most of the large amount of water contained in peat, without which processes of distillation prove barely remunerative.

We must therefore rely chiefly on our coal reserve for our supply of energy, and for the means of supporting our population; and it is to the more economical use of coal that we must look, in order that our life as a nation may be prolonged. We can economise in many ways: By the substitution of turbine engines for reciprocating engines, thereby reducing the coal required per horse-power from 4 to 5 lb. to 1½ or 2 lb.; by the further replacement of turbines by gas engines, raising the economy to 30 per cent. of the total energy available in the coal, that is, lowering the coal consumption per horse-power to 1 or 1¼ lb.; by creating the power at the pit-mouth, and distributing it electrically, as is already done in the Tyne district. Economy can also be effected in replacing 'bee-hive' coke ovens by recovery ovens; this is rapidly being done; and Dr. Beilby calculates that in 1909 nearly six million tons of coal, out of a total of sixteen to eighteen millions, were coked in recovery ovens, thus effecting a saving of two to three million tons of fuel annually. Progress is also being made in substituting gas for coal or coke in metallurgical, chemical, and other works. But it must

be remembered that for economic use, gaseous fuel must not be charged with the heavy costs of piping and distribution.

The domestic fire problem is also one which claims our instant attention. It is best grappled with from the point of view of smoke. Although the actual loss of thermal energy in the form of smoke is small—at most less than a half per cent. of the fuel consumed—still the presence of smoke is a sign of waste of fuel and careless stoking. In works, mechanical stokers which ensure regularity of firing and complete combustion of fuel are more and more widely replacing hand-firing. But we are still utterly wasteful in our consumption of fuel in domestic fires. There is probably no single remedy applicable; but the introduction of central heating, of gas fires, and of grates which permit of better utilisation of fuel will all play a part in economising our coal. It is open to argument whether it might not be wise to hasten the time when smoke is no more by imposing a sixpenny fine for each offence; an instantaneous photograph could easily prove the offence to have been committed; and the imposition of the fine might be delayed until three warnings had been given by the police.

Now I think that what I wish to convey will be best expressed by an allegory. A man of mature years who has surmounted the troubles of childhood and adolescence without much disturbance to his physical and mental state, gradually becomes aware that he is suffering from loss of blood; his system is being drained of this essential to life and strength. What does he do? If he is sensible he calls in a doctor, or perhaps several, in consultation; they ascertain the seat of the disease and diagnose the cause. They point out that while consumption of blood is necessary for healthy life, it will lead to a premature end if the constantly increasing drain is not stopped. They suggest certain precautionary measures; and if he adopts them, he has a good chance of living at least as long as his contemporaries; if he neglects them, his days are numbered.

That is our condition as a nation. We have had our consultation in 1903; the doctors were the members of the Coal Commission. They showed the gravity of our case, but we have turned a deaf ear.

It is true that the self-interest of coal consumers is slowly leading them to adopt more economical means of turning coal into energy. But I have noticed and frequently publicly announced a fact which cannot but strike even the most unobservant. It is this: When trade is good, as it appears to be at present, manufacturers are making money; they are overwhelmed with orders, and have no inclination to adopt economies which do not appear to them to be essential, and the introduction of which would take thought and time, and which would withdraw the attention of their employés from the chief object of the business—how to make the most of the present opportunities. Hence

improvements are postponed. When bad times come, then there is no money to spend on improvements; they are again postponed until better times arrive.

What can be done?

I would answer: Do as other nations have done and are doing; take stock annually. The Americans have a permanent Commission initiated by Mr. Roosevelt, consisting of three representatives from each State, the sole object of which is to keep abreast with the diminution of the stores of natural energy, and to take steps to lessen its rate. This is a non-political undertaking, and one worthy of being initiated by the ruler of a great country. If the example is followed here, the question will become a national one.

Two courses are open to us; first, the *laissez-faire* plan of leaving to self-interested competition the combating of waste; or second, initiating legislation which, in the interest of the whole nation, will endeavour to lessen the squandering of our national resources. This legislation may be of two kinds: penal, that is, imposing a penalty on wasteful expenditure of energy-supplies; and helpful, that is, imparting information as to what can be done, advancing loans at an easy rate of interest to enable reforms to be carried out, and insisting on the greater prosperity which would result from the use of more efficient appliances.

This is not the place, nor is there the time, to enter into detail; the subject is a complicated one, and it will demand the combined efforts of experts and legislators for a generation; but if it be not considered with the definite intention of immediate action, we shall be held up to the deserved execration of our not very remote descendants.

The two great principles which I have alluded to in an earlier part of this address must not, however, be lost sight of; they should guide all our efforts to use energy economically. Concentration of energy in the form of electric current at high potential makes it possible to convey it for long distances through thin and therefore comparatively inexpensive wires; and the economic coefficient of the conversion of mechanical into electrical, and of electrical into mechanical energy is a high one; the useless expenditure does not much exceed one-twentieth part of the energy which can be utilised. These considerations would point to the conversion at the pit-mouth of the energy of the fuel into electrical energy, using, as an intermediary, turbines, or preferably gas engines; and distributing the electrical energy to where it is wanted. The use of gas engines may, if desired, be accompanied by the production of half-distilled coal, a fuel which burns nearly without smoke, and one which is suitable for domestic fires, if it is found too difficult to displace them and to induce our population to adopt the more efficient and economical systems of domestic heating which are used in

America and on the Continent. The increasing use of gas for factory, metallurgical, and chemical purposes points to the gradual concentration of works near the coal mines, in order that the laying-down of expensive piping may be avoided.

An invention which would enable us to convert the energy of coal directly into electrical energy would revolutionise our ideas and methods, yet it is not unthinkable. The nearest practical approach to this is the Mond gas-battery, which, however, has not succeeded, owing to the imperfection of the machine.

In conclusion, I would put in a plea for the study of pure science, without regard to its applications. The discovery of radium and similar radioactive substances has widened the bounds of thought. While themselves, in all probability, incapable of industrial application, save in the domain of medicine, their study has shown us to what enormous advances in the concentration of energy it is permissible to look forward, with the hope of applying the knowledge thereby gained to the betterment of the whole human race. As charity begins at home, however, and as I am speaking to the *British* Association for the Advancement of Science, I would urge that our first duty is to strive for all which makes for the permanence of the British Commonweal, and which will enable us to transmit to our posterity a heritage not unworthy to be added to that which we have received from those who have gone before.

REPORTS
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STATE OF SCIENCE.

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Establishing a Solar Observatory in Australia.—Report of the Committee, consisting of Sir DAVID GILL (*Chairman*), Dr. W. G. DUFFIELD (*Secretary*), Dr. W. J. S. LOCKYER, Mr. F. McCLEAN, *and* Professors A. SCHUSTER *and* H. H. TURNER.

THE movement has gained ground steadily during the past year, and it is evident from the support it has received that much more widespread sympathy has been accorded to it than could have been anticipated at the outset. In Australia, where there exists a Solar Physics Committee to co-operate with the British Association Committee to promote the proposed Solar Observatory, the movement has been once more the subject of a favourable resolution by the Council of the Australasian Association for the Advancement of Science, and public attention has been recalled to the subject by the expedition of British astronomers that passed through Australia *en route* for the solar eclipse observation at Vavau, in particular by Dr. Lockyer and Father Cortie.

In England the desirability of Australian co-operation in solar research has been emphasised in several ways. Speaking at the Royal Society of Arts the Permanent Secretary of the Commonwealth Office described Australia's eagerness to share in those pursuits of science in which she is best fitted to participate, and referred to the action taken by Mr. Deakin's Cabinet in offering the annual upkeep of this observatory provided that 10,000*l*. were forthcoming from private sources for its equipment. The British Empire League has accorded the proposal its hearty sympathy, and is now vigorously assisting the project by an active appeal to its members and sympathisers to support the movement.

It seemed opportune to take advantage of Mr. Fisher's presence in London to advance the observatory scheme, and a deputation was formed to wait upon him. The Royal Astronomical Society appointed the Astronomer-Royal, Sir David Gill, and Professor Newall to attend this deputation, the British Empire League being represented by Lord

Avebury, and this Committee by the Chairman and Secretary. In the unavoidable absence of the Prime Minister of the Commonwealth at an extraordinary meeting of the Imperial Conference, the deputation was received by Mr. Batchelor, the Minister of External Affairs of the Commonwealth.

Sir David Gill, leading the deputation, referred to the gap in longitude which it is necessary to fill before the complete scheme of solar research can be effected, a gap which an Australian Solar Observatory would obviate, and pointed out her unique position south of the Equator. He mentioned the fact that the British Association had voted the sum of 50*l.* towards the scheme, and asked on behalf of the Committee that the Australian Government would relieve him of the responsibility of this money by promoting the object for which it had been voted. He trusted that the work done by existing State observatories would not be interfered with by the establishment of a new observatory for the study of the sun.

Professor Newall emphasised the need for a station in Australia on the ground that continuous observations of the sun were required, and spoke of the possibility of solar research proving of value to the meteorologist.

The Astronomer-Royal referred to the excellent climatic conditions of Australia for solar observations. He pointed out the great theoretical value of a close study of the sun in its relation to the study of the physical conditions of the stars and of their development. He emphasised the importance of research work being carried on because of its educational value, and expressed the view that the existence of a Solar Observatory would stimulate the study of physics generally as well as astrophysics in the Universities of Australia.

Lord Avebury dwelt upon the unusual support that has been accorded to this scheme by learned societies, and suggested that such an observatory if established would ensure three of the four links in the chain of solar stations round the earth being within the British Empire, and all four—the British, Indian, Australian, and American—being conducted by English-speaking peoples.

Dr. Duffield referred to the progress of the movement in Australia, to the previous action of the Fisher Ministry in offering 1*l.* for 1*l.*, to the vigorously supported public meeting in Melbourne, and to Mr. Deakin's promise of the upkeep provided 10,000*l.* were privately subscribed. He further stated that over 4,000*l.* had already been offered in money and apparatus, and that this was a sufficiently substantial sum to convince the Government that the people of Australia are in earnest in the matter. The Press of Australia were unanimous in its favour.

The Minister, in reply, stated that he was impressed with the desirability of filling the gap in longitude, but that before action could be taken it would be necessary to consult the other members of the Cabinet. This would be done upon his return to Australia, and he personally promised to urge upon the Prime Minister and his colleagues the desirability of establishing a Solar Observatory in Australia.

Investigation of the Upper Atmosphere, in co-operation with a Committee of the Royal Meteorological Society.—Tenth Report of the Committee, consisting of Dr. W. N. SHAW (*Chairman*), Mr. E. GOLD (*Secretary*), Messrs. D. ARCHIBALD, C. VERNON BOYS, C. J. P. CAVE, *and* W. H. DINES, Dr. R. T. GLAZEBROOK, Sir JOSEPH LARMOR, Professor J. E. PETAVEL, Dr. A. SCHUSTER, *and* Dr. W. WATSON.

MEETINGS of the Joint Committee were held in the rooms of the Royal Meteorological Society on October 12, 1910, and March 28, 1911.

The results of the observations at Barbados, referred to in last year's Report, were discussed by Mr. Cave in a paper read before the Royal Meteorological Society and published in its Quarterly Journal. A further supply of balloons and hydrogen were sent to Professor D'Albuquerque in order that he might continue the observations.

During the week August 7-13, 1910, for which international balloon ascents had been arranged over a large part of the Northern hemisphere, arrangements similar to those described in last year's Report were made for securing successful ascents in the British Isles. Altogether 31 balloons were liberated, of which 19 were recovered and 16 gave records of temperature to heights exceeding 10 km. Of the latter five were sent up from Crinan, N.B., five from Pyrton Hill, Oxfordshire, three from Manchester, two from Ditcham Park, Petersfield, and one from Oughterard, Ireland.

The British Association grant was allocated partly to ascents made by Captain Ley at Oughterard, latitude 53° 25′ N., longitude 9° 20′ W., in the West of Ireland, and partly to ascents made from Mungret College, Limerick. At Oughterard six registering balloons were sent up, and two of these were recovered. The results are shown in the Table of Ascents (A) and (B).

At the March meeting of the Committee it was suggested that the authorities of Mungret College, Limerick, who had given evidence of keen interest in meteorological work, might be willing to liberate balloons during the international week. Such a course would avoid the recurrent expense involved in special journeys to Ireland for the ascents, and would permit of more frequent ascents being made. The College authorities expressed their willingness to fall in with the suggestion, and Mr. W. H. Dines undertook to provide instruments and balloons for preliminary ascents in connection with the short international series in June this year, and to send over his assistant to give necessary instructions in the preparation for the ascents.

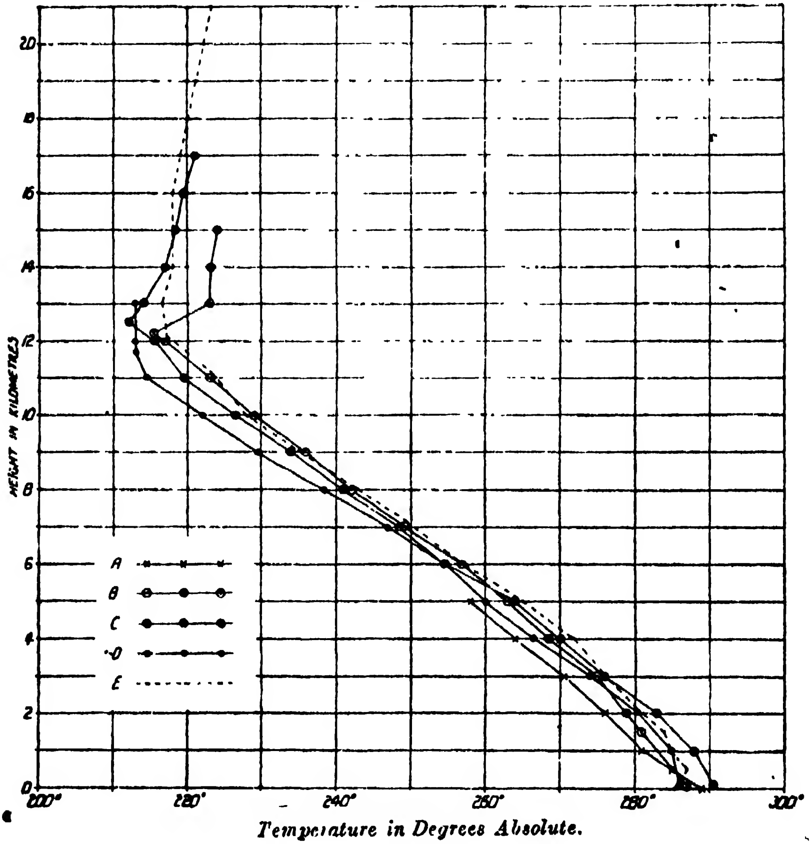
Three balloons were liberated on this occasion, and two of them were recovered and gave records of temperature, in one case up to 17 km. The results are shown in the Table of Ascents (C), (D). A balloon was also liberated from Mungret College in July, and the result is shown under (E). The results for all five cases are plotted in the diagram.

At the request of the Joint Committee the week for international ascents this year was postponed from September 4-9 to September 11-16,

in order to permit of those taking part in the ascents attending the meeting of the Association at Portsmouth.

Arrangements have been made for further ascents from Mungret College during that week.

Results of Balloon Ascents in Ireland, 1910–11.



It is desirable that observations of pilot balloons should be obtained in Ireland in addition to the records from registering balloons, and the Committee recommend reappointment, with a grant of 50*l.*, to permit of this extension of the work. A special theodolite, costing about 30*l.*, is necessary for the observations. The additional outlay on balloons and hydrogen for the pilot-balloon observations would be comparatively small.

In the Table pressure is expressed in megadynes per cm^2, temperature in degrees Centigrade above the absolute zero—273° on the ordinary scale. H_c is the height and T_c the temperature at which temperature begins to be practically constant in a vertical direction.

Results obtained from Ascents of Registering Balloons in Ireland.

Height km.	AUGUST 1910.				JUNE 1911.						JULY 1911.	
	A		B		C			D			E	
	Oughterard, August 8, 8.10 P.M.		Oughterard, August 11, 7 A.M.		Limerick, June 8, 7 A.M.			Limerick, * June 9, 7.10 A.M.			Limerick, July 6, 7.10 A.M.	
	Pressure mgd.	Temp. °A	Pressure mgd.	Temp. °A	Pressure mgd.	Temp. °A		Pressure mgd.	Temp. °A		Pressure mgd.	Temp. °A
Ground	1·013	289	1·013	287	1·025	290·5		1·017	286		1·024	285·5
0·5	0·955	285	—	?	0·968	289		0·959	284·5		0·978	287
1·0	0·893	281	—	?	0·914	287	280	0·904	283	287	0·924	285
1·5	0·841	278·5	0·848	281	0·860	285	287	0·853	282	284	0·871	284
2·0	0·794	276	0·799	279	0·811	282	284	0·804	280·5	281·5	0·818	281
2·5	0·745	273	0·751	278	0·764	278	280	0·756	276	277	0·769	278
3·0	0·700	270·5	0·707	275	0·719	275	276·5	0·712	273	274·5	0·724	275·5
3·5	0·658	267	0·664	271	0·678	272	274	0·670	270	272	0·683	274
4·0	0·618	264	0·624	268·5	0·636	269	271·5	0·628	266	267·5	0·641	272
4·5	0·582	261	0·587	266	0·598	266	268·5	0·591	263		0·604	269
5·0	0·547	258	0·551	263	0·561	263	265	0·552	260		0·565	265
5·5	—	—	0·516	260	0·527	258	260	0·516	256·5	258	0·528	260·5
6·0	—	—	0·485	257	0·492	253	256	0·484	254	256	0·496	257
6·5	—	—	0·452	254	0·461	251	252	0·458	249·5	252	0·464	252·5
7·0	—	—	0·424	249	0·431	247	250	0·422	246	248·5	0·434	249
7·5	—	—	0·395	244	0·403	243·5	246	0·395	242	245	0·405	247
8·0	—	—	0·368	242	0·376	240	242	0·368	237	240	0·377	240
8·5	—	—	0·344	239	0·351	236·5	238	0·342	232	235	0·352	239
9·0	—	—	0·321	236	0·325	233	235	0·318	228	231	0·328	235
9·5	—	—	0·298	233	0·302	229·5	232	0·297	224	227	0·304	231·5
10·0	—	—	0·278	229	0·283	225	228	0·276	220	224	0·284	228
11·0	—	—	0·241	228	0·243	218	221	0·236	215	214	0·244	223
12·0	—	—	0·208	217	0·209	214	216·5	0·208	213		0·211	217
13·0	—	—	0·178	223	0·178	212·5	215·5	0 173	213		0·180	216·5
14·0	—	—	0·154	223	0·154	216	218	—	—		0·155	218
15·0	—	—	0·131	224	0·131	216	221	—	—		0·132	218
16·0	—	—	—	—	0·111	218	221	—	—		0·114	218
17·0	—	—	—	—	0·096	221		—	—		0 097	219
18·0	—	—		—	—			—	—		0·081	220
19·0	—	—	—	—	—	—		—	—		0·072	221
20·0	—	—	—	—	—	—		—	—		0·061	222
21·0	—	—	—	—	—	—		—	—		0·053	223
Max. Height . .	5·0 km.		15·0 km.		17·0 km.			13·0 km.			21·0 km.	
Minimum Temperature	—		216° (at 12·2 km.)		212° (at 12·5 km.)			213° (from 11·7 to 13 km.)			216° (at 12·7 km.)	
Place of fall . .	Clear Island, Co. Mayo		Moyvore, Westmeath		Kildysart			Buttevant			Cooleeney	
Distance	? 50 km.		88 km.		31 km.			48 km.			56 km.	
Direction* . . .	? 0°		80°		280°			185°			68°	
H_c T_c	—		12 km., 217°		12·5 km., 212°, 216°			11·7 km., 213°			12·7 km., 216°	

Notes—

B. The heights above 8 km. are rather doubtful, as the original calibration marks relating to the pressure are uncertain, and the instrument was returned badly damaged.

C. Wind E.N.E., light. Faint cirrus.

D. Wind N.E., force 3. Cumulus, no high clouds. A rather different type of instrument was used, and the double record may be in part due to lag.

E. Calm, cloudy, cirrus moving slowly from W.

* Direction 0° = N, 90° = E

Seismological Investigations.—Sixteenth Report of the Committee, consisting of Professor H. H. TURNER (*Chairman*), Mr. J. MILNE (*Secretary*), Mr. C. VERNON BOYS, Sir GEORGE DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Dr. R. T. GLAZEBROOK, Mr. M. H. GRAY, Mr. R. K. GRAY, Professor J. W. JUDD, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Mr. CLEMENT REID, Professor R. A. SAMPSON, *and* Professor A. SCHUSTER. (*Drawn up by the Secretary.*)

[PLATES I. AND II.]

CONTENTS.

I. *General Notes.*

THE Committee seek to be reappointed with a grant of 60*l*.

Registers.—During the last year Circulars Nos. 22 and 23 have been issued. They refer to Shide, Kew, Bidston, Edinburgh, Paisley, Eskdalemuir, Guildford, Stonyhurst, West Bromwich, Haslemere, San Fernando, Ponta Delgada, Toronto, Victoria, B.C., Beirut, Cairo, Valletta, Cape of Good Hope, Bombay, Kodaikanal, Colombo, Honolulu, Perth, Sydney, Wellington, Christchurch, Baltimore, Mauritius, Cape Verde, Ascension, Calcutta, and Adelaide.

Visitors.—During the last year many people visited the observatory at Shide. Among those who came for instruction or to obtain special information were the following: Prince B. Galitzin; G. Raymond, H.M. Consul at Corfu; Professor B. Mano, of the Earthquake Investigation Committee of Japan; Professor H. H. Turner; J. Woodrow, Coats Observatory; P. J. Hood, Eastern Telegraph Company; M. H. Gray; T. Chance, Cardiff; Professor J. Swain, Cork University; G. H. Harrison, in connection with Tidal Load instrument at Ryde; Colonel G. Elliott, R.E.; W. E. Jenkin, Rio Tinto Mines, Spain; Sir Daniel Morris, who has given assistance in establishing an instrument in the West Indies; W. G. Freeman, Trinidad; F. H. Longhurst, Deputy Director of Public Work, Accra; Members of the Science Section of the Bournemouth Natural History Society; B. F. E. Keeling, Cairo.

Seismological Exhibition.—At the suggestion of the Science Committee of the Coronation Exhibition at the White City, I organised a Seismological Section. This Committee communicated with most of

our Colonies and with individuals and institutions in Great Britain, with the object of obtaining exhibits. Mr. M. H. Gray sent a large map of the world, 30 feet by 15 feet, which shows stations co-operating with the British Association and the centres of marked seismic activity. I sent a tidal-load recording instrument made in Newport, and through Mr. R. W. Munro, a British Association type of seismograph. The Rev. Father W. O'Leary forwarded a model of a new type of seismograph which he is using at the Mungret College, Limerick. In the Machinery Hall, Mr. J. J. Shaw, of West Bromwich, erected a pair of horizontal pendulums which, notwithstanding the varying loads and vibrations to which they are subjected, have recorded several large earthquakes. These with other instruments, enlargements of seismograms and various pictures, constitute the chief features amongst the exhibits. I mention this matter because it is the first exhibition of its kind in this country, and also because it has done very much to call attention to a new science.

New Stations.—Mr. W. Davis, Director of the Meteorological Office, Argentina, is establishing at least three new stations at which the British Association type of instrument will be used. Another instrument is to be established at the University of Cork, and one at Cardiff is now in working order. The instruments despatched last year to Cape Verde, Ascension, Fernando Noronha, and St. Helena have been installed and records are being obtained from these places. Those sent to the Seychelles, Cocos, and Fiji have arrived at these places and we may shortly expect to receive records from the same. I may here mention that the instrument at Fernando Noronha, like the one at San Fernando in Spain, was purchased for our benefit by Mr. Robert K. Gray. The instrument purchased by the Pacific Cable Company to be used at Fanning has not yet reached that island. The reason for the delay is that an officer from that island has not been in England to receive instructions, and it is seldom that the island is visited.

The Colonial Office have kindly sent out circulars to Governors and other officers in Colonies bordering the Eastern and Western sides of the Atlantic inviting them to co-operate in the seismological work of the British Association. These include Newfoundland, Bermuda, Barbados, Jamaica, and Turks Island; other islands in the West Indies, Guiana, Honduras, the Falklands and the Gold Coast. Mr. Joseph Rippon of the West India Cable Company has given great assistance towards the furtherance of this object.

On March 28, 1911, the Legislative Council of Bermuda passed a 'Seismographic Act' enabling the Board of Public Works to purchase and maintain a seismograph.

On behalf of the International Seismological Association I have sent out to stations co-operating with the British Association a circular which states that the Central International Bureau at Strasburg is prepared to test earthquake instruments. These tests will be made free of cost for stations in countries which have joined the International Association, but for others there will be a charge of from 100 to 150 marks. An enclosure with this circular asks for material to complete a macroseismic catalogue for 1907.

II. *Double and Multiple Earthquakes.*

Attention has frequently been drawn to the fact that an earthquake as it radiates may cause a collapse of strata which are in an unstable condition and thus give rise to one or more secondary disturbances.[1] The great earthquake of Lisbon in 1755 gave rise to secondary shocks in England and Ireland, and probably in many other countries. In the volume containing Physical Observations made in the Antarctic Regions in 1902-03, published under the superintendence of the Royal Society, page 92, I gave illustrations of secondary earthquakes the genesis of which corresponded in time to the arrival of certain phases of primary disturbances. That the large waves of a seismic disturbance as they travel round the world causing the crust of the same to rise and fall like a raft on an ocean swell should give rise to one or more secondary disturbances is not surprising. Further than this, any of the latter which may be *greater or less than* their parent may in turn become the originator of further settlements. One megaseism may therefore cause a relief of seismic strain throughout the world. An indication of this is seen in the fact that large earthquakes originating in widely separated districts frequently occur in groups. This idea I wish to extend to the possibility of secondary earthquakes originating in consequence of mass displacement or 'push' exerted in a hypofocal region, or on the arrival of waves of the type P_1 and P_2, the speeds of which are relatively about four times and twice those of P_3. This means that an earthquake originating at A might result in reliefs of strain in distant localities B, C, D, &c., on the arrival of P_1 which radiated from A. The seismograms obtained at stations near to B, C, D would on account of the differences in the times of arrival of P_1 at these places coinciding with what we should expect, be attributed to the primary impulse originating at A and not to impulses which had been brought into existence in the neighbourhood of B, C, and D. Generally this supposition is correct, but instances occur where it fails to explain the amplitudes of movement and the times of arrival of P_3 or the maximum movement recorded at these latter stations. It has been shown that stations at great distances from the origin of a megaseism may record movements which have travelled to them in opposite directions round the world. This might, at a distant station, give rise to at least two maxima and a lengthening of the duration of motion. These phenomena may also find a partial explanation in the hypothesis of reflections within our world, or the echoes from mountain roots.[2] What I now suggest is that these unexplained characteristics of certain seismograms may partly be the outcome of secondary disturbances the existence and importance of which has hitherto been unrecognised.

Example 1.—*Guatemala Earthquake, April* 19, 1902.

On April 19, 1902, a violent earthquake took place in Guatemala. It partly obliterated Quezaltenango, Amititlan, and bady damaged many other places. It was accompanied by fires. If it could be shown that the fires broke out before the earthquake certain fire insurance companies were liable. On the other hand, if the fires occurred with or

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[1] See *Earthquakes*, 'International Science Series,' p. 248.

[2] See *Brit. Assoc. Reports*, 1899, p. 227; 1900, p. 71

immediately after the earthquake and could therefore be regarded as a consequence of the same, the companies were free from liability. The result was that a careful inquiry was instituted as to the exact time of the earthquake. This involved consultations with observatories near to and at great distances from the stricken district as to the exact time at which the earthquake had taken place. The result of these investigations was that 2.22 P.M. in G.M.T. was adopted as the time of the disaster, but from information received since this inquiry, I am led to think that a safer estimate is 2.21 ± .1 minute.

The records taken at stations all over the world, if we only consider the times at which the first motion or P_1 was noted, lead with certain variations to the same conclusion. Observatories in all the continents rightly concluded that their records referred to the Guatemala earthquake, but the idea that these records might also refer to several other earthquakes does not appear to have been considered.

We expect maxima to recur at regularly spaced intervals when the period of the pendulum approximates to that of the ground. Recurrences of maxima at varying intervals which we have here to consider suggest a variable period in the movement of the ground. Although this supposition may be true, it does not preclude the idea that accretions of activity may arise from the generation of secondary disturbances.

Mr. R. D. Oldham, who has made a careful study of this earthquake (see Proceedings of the Royal Society, vol. 76) writes to me as follows: 'It seemed as if the well-defined maximum at 90° to 100° was due to the combined effect of a group of waves, the faster travelling having caught up the slower at about that distance, and these as they travelled on separated again giving a long drawn out seismogram with no defined maximum but a series of bulges, due partly to interference of the waves travelling at different rates and partly to interference between these and the swing of the pendulum.'

With regard to this earthquake we know that it originated about 2.21, and records from stations on the American continent, whatever phase of motion we consider, support this conclusion. Very distant stations from Guatemala, however, only fall in line with this so far as P_1 is concerned. This first maximum recorded at Capetown 2h. 58m., Calcutta 3h. 13m., Bombay 3h. 8m., Kodaikanal 3h. 6m., and Perth 3h. 4m., apparently refers to an epicentre in the Indian Ocean, which lies about 60° East and 35° South, and not to Guatemala. This disturbance originated at about 2h. 34m. The second maximum at Capetown 3h. 26m., Bombay 3h. 43m., Kodaikanal 3h. 52m., and Perth 3h 4m., approximately accords with Guatemala. The difference in time between the Guatemala shock and the one in the Indian Ocean is about fourteen minutes. The time taken for a compressional wave to travel between these two origins, or 146°, would be about 21m. This being so, unless we admit an error of six or seven minutes in one of these time determinations, which might easily be the case, we cannot say that the second earthquake was brought about by compressional waves from Guatemala. A relationship is not proven, it is only suggested. First of all it may be noticed for this earthquake, and also for others, that the ground moved for a longer time at very distant stations from the epicentre than it did at stations which were comparatively near to the same. At Baltimore, Toronto, Victoria, Cordova, Edinburgh,

Bidston, San Fernando, Shide, and Kew, the distances of which from the epicentre lie between 27° and 79°, the average duration of movement was 2h. 32m.; whilst at Christchurch, Tokio, Irkutsk, Capetown, Calcutta, Bombay, Perth, Kodaikanal, and Batavia the epicentral distances of which lie between 104° and 160°, the average duration was 2h. 51m.; the durations for Capetown and Christchurch were respectively 4h. 52m. and 3h. 19m.—the longest recorded in the world. One explanation for these observations is the assumption that the flood of motion set free in Guatemala had been augmented as it travelled.[1]

Amplitudes point in the same direction. At Wellington, New Zealand, the pointers were driven off the recording surface, and the seismogram suggested that the earthquake had originated near to that place rather than in Guatemala, which is 103° distant. Although this particular record is exceptional, the seismograms from quadrantal regions do not exhibit the great falling off in amplitude which we should anticipate.

Another indication of reinforcement is in the repeated maxima seen in seismograms obtained at different stations.

The records from Manila 2.46, Tokio 2.51, Irkutsk 2.51, and Wellington 3.39 may be explained by the assumption that at about 2.36 an earthquake originated at 113° E. and 27° N.

The Wellington maximum which exceeded 15 min., it will be observed, roughly agrees with each of the three epicentres which have been considered—that is to say, maxima movements from three centres reached Wellington at nearly the same time.

All the observations to which I have referred were made with similar installed instruments.

Example 2.—The Arica Earthquake, December 26, 1906.

On December 26, 1906, at 5.56 A.M. G.M.T., an earthquake wrecked several houses in Arica and was felt severely in Iquique and Pisagua. From local observations and observations made in Cordova and Trinidad I should place the origin about 3° or 4° from Arica, and conclude that the disturbance originated a few minutes before it was recorded in that city. A certain number of minutes after the Arica earthquake seismograms were obtained at observatories in the West Indies, North and South America, Great Britain, Europe, Siberia, India, Australia, Batavia, China, Manila, and Capetown. These are more than fifty in number, and because their commencements are approximately at times we should expect P_1 to reach these various stations from an origin off the North coast of Chile, seismologists have attributed these various records to the Arica earthquake. They however indicate that the time at which it originated was at 5.51 or 5.52, which is about 2 min. earlier than the time I have just suggested.[2]

A close examination of these numerous records, however, shows that those relating to P_2, P_3, and, I may add, amplitudes, do not lead to the same conclusions as those derived from a discussion of those referring

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[1] See *Brit. Assoc. Reports*, 1908, p. 72.

[2] *Ibid.*, 1907, p. 86, fig. 1323 on the map (Milne); *Bollettino della Società Sismologica Italiana*, Appendice, vol. 13, p. 511 (Martinelli); and the Publications du Bureau Central de l'Association Internationale de Sismologie, Catalogues 1906, p. 84 (Szirtes).

to P_1. Observations made in the Azores, San Fernando, Bidston, Shide, Messina, Rome, Tiflis, Colombo, and Irkutsk, point to an origin in the Atlantic about 18° W. and 38° N., which is not far from the Azores, where the amplitude was large. The time of the initial shock would be 6.4 ± 2 min., or approximately 12 min. after the Arica disturbance. Now the distance from Arica to the Atlantic origin is 75°, and this would be traversed by P_1 in 14 min. Although it may not be certain, it seems at least probable that the disturbance near to the Azores was brought into existence by the arrival of preliminary tremors which had originated off the western coast of Chile. A similar line of reasoning applied to the records from Honolulu, Batavia, and a second maximum seen in the Irkutsk seismogram suggests that a third disturbance had taken place in mid-Pacific.

Other Examples of Multiple Earthquakes.

In the following list I give the date and times at which these occur; after that the longitude and latitude of their origins and the distances that these are apart expressed in degrees. Lastly, I give the time we should expect P_1, P_2, or P_3 to traverse the distance between any two origins and compare this with the difference in time between the occurrence of each pair of earthquakes.

Date	Time	Position	Distance	Time expected in minutes	Actual time in minutes
1899, July 11 .	7.29±3	140 E. 15 N.	132°	P_1, 9	7 ca.
	7.36±3	42 W. 35 N.			
1899, July 14 .	13.34±2	150 W. 60 N.	98°	P_1, 8	6
	13.40	33 E. 23 N.			
1899, Nov. 24 .	18.39	136 E. 5 N.	30°	P_1, 6	2
	18.41	132 E. 33 N.			
1900, Nov. 9 ..	16.7±2	96 W. 11 N.	112°	P_3, 70	106
	17.53	139 E. 34 N.			
1900, Dec. 18 .	22.4±2	125 W. 67 S.	83°	P_3, 53	71
	23.15±2	120 W. 27 N.			
1902, April 11 .	23.41	110 E. 50 N.	155°	P_1, 22	14
	23.55	65 W. 27 S.			
1902, Sept. 22 .	1.44	130 E. 30 N.	50°	P_1, 10	2
	1.46	175 E. 75 N.			
	1.56	152 E 52 S.	85°	P_1, 15	12
1902, Sept. 23 .	20.16	90 W. 15 N.	134°	P_1, 21	13
	20.29 ca.	77 E. 60 S.			
1902, Nov. 15 .	9.30	128 E. 20 N.	45°	P_1, 9	3
	9.33	105 E. 20 S.			
1903, Sept. 7 .	7.10	75 E. 71 S.	100°	P_1, 16	4
	7.14	122 E. 23 N.			
1903, Dec. 6 .	22.48	45 E. 41 S.	71°	P_3, 45	44
	23.32	31 E. 30 N.	Felt in Cairo		
1904, Oct. 9 .	13.51	15 W. 70 N.		P_3, 8	9
	14.0	Felt at Namdalen, Norway			
	14.15	Quito	81°	P_2, 24	24
1906, Mar. 27 .	5.0	55 W. 52 S.	156°	P_1, 22	23
	5.23	120 E. 78 N.			
1906, June 20 .	2.25	89 W. 13 N.	140°	P_3, 78	76
	3.41	121 E. 18 N.	Felt in N. Luzon		
1906, Aug. 17 .	0.6	168 E. 31 N.	132°	P_3, 32	35
	0.41	72 W. 33 S.			

III. *Seismic Activity in Japan, Italy, and America during the years* 1700-1900. By F. M. Walker, *B.A.*

With the object of finding, if possible, some well-marked synchronism between the periods of maximum seismic activity in the three widely separated districts, the following plan was adopted:—

An experimental period of eleven years was decided upon, and the total activity of each area during this 'undecade' was calculated. This was done by adding together the intensities of all destructive earthquakes recorded for that period. Thus, for example, 7 earthquakes of Intensity III, 13 of Intensity II, and 25 of Intensity I would give a total for the eleven years of 72. This divided by 11 gives the average activity for each year of that period, viz., 6.5. In this manner eighteen such averages were calculated for each area and plotted, see p. 37.

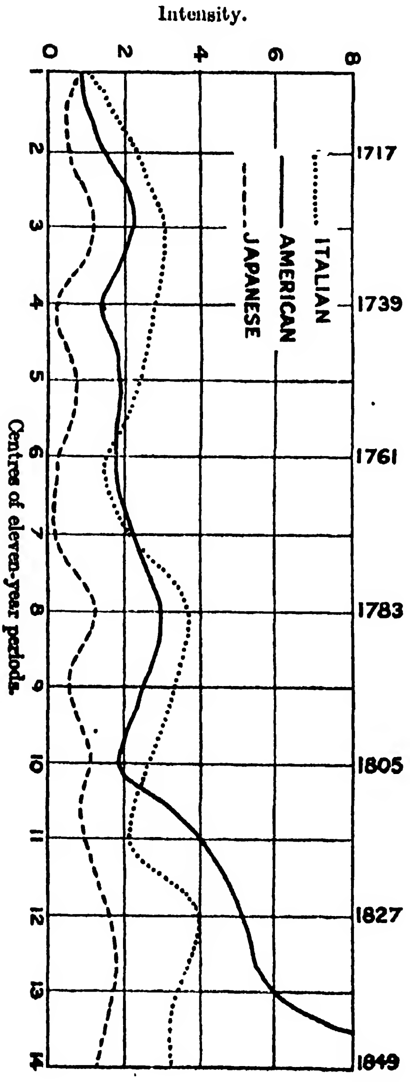
With regard to synchronism, the results were not very definite. The three curves show agreement at (1723-33), and again (1778-88), and in a less marked degree (1823-33). The curves for Japan and Italy show agreement at (1723-33), (1778-88), (1823-33), (1889-99) for a high average, and synchronic periods of declining activity for (1756-66), (1767-77), and (1812-22).

IV. *On the Synchronism of Seismic Activity in different Districts.*

In the British Association Report for 1908, p. 64, I pointed out that since 1902 seismic activity had fluctuated similarly on the East and West sides of the North Pacific. I returned to this subject in the Report for 1909, pp. 57 and 58, and showed that during the last three hundred years the times of activity in Italy, although separated from each other by irregular intervals, had varied between five and twenty years, and that these dates of activity in Europe closely corresponded to the dates when there had been marked activity in Japan. In consequence of additions which have been made during the last twelve months to a catalogue of destructive earthquakes of the world, I have been able to extend this inquiry and compare the times of earthquake activity or quiescence of the four following important but widely separated regions: the Italian Peninsula, including Sicily; Japan, Formosa, and the Philippines; North, South, and Central America; and China. The only earthquakes considered are those which have been destructive, and for brevity I refer to the four regions A, B, C, D.

The analyses only refer to the last two hundred years (1700-1899). The reason I have confined the examination to this particular period is that the records for the Philippines, and for the two Americas in particular, prior to the year 1700 are but few in number.

Because there has been an increase in the number of records kept in any given country as we approach modern times, but not necessarily an actual increase in the number of earthquakes which have taken place, to determine whether the number of records in a district for any


Intensity.
0
2
4
6
8
1
2
3
4
5
6
7
8
9
10
11
12
13
14
1717
1739
1761
1783
1805
1827
1849
ITALIAN
AMERICAN
JAPANESE
Centres of eleven-year periods.

given year represent an increase or decrease in activity, I have compared such numbers with the average number which took place in a certain period of years. The first average taken for all districts is for the years 1700 to 1734. For Italy this, for example, is found to be 1·7 per year. Any year during which more than two large earthquakes were noted is therefore a year in which seismic activity has been above the average. The remaining periods are each of thirty-three years, and respectively end in the year 1767, 1800, 1833, 1866, and 1899. The years in which these four widely separated districts, A, B, C, and D, have shown abnormal activity are the following: 1720, 1730, 1731, 1732, 1746, 1751, 1755, 1785, 1822, 1831, 1853, and 1885 (twelve times). There was comparative quiescence for all four districts in the years 1704, 1708, 1710, 1744, 1745, 1757, 1758, 1761, 1837, 1843, 1848, 1877, 1890, 1896, and 1899 (fifteen times).

Three districts have shown unusual *activity*, while there has been comparative quiescence in one in the following years: 1700, 1703, 1705, 1707, 1714, 1716, 1718, 1719, 1725, 1736, 1739, 1740, 1743, 1752, 1753, 1756, 1762, 1782, 1787, 1791, 1794, 1797, 1806, 1809, 1812, 1818, 1819, 1821, 1827, 1828, 1829, 1830, 1834, 1852, 1857, 1861, 1862, 1864, 1865, 1866, 1874, 1875, 1887, 1889, 1893, 1894 (forty-six times).

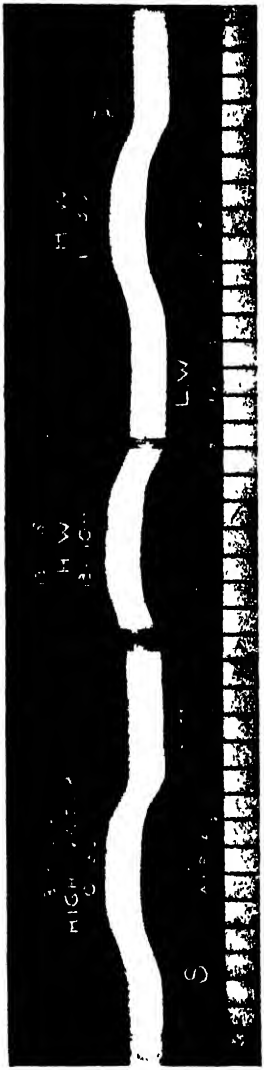
Three districts have shown unusual *quiescence* while there has been comparative activity in one, in the following years: 1701, 1709, 1712, 1728, 1733, 1734, 1737, 1738, 1741, 1748, 1750, 1760, 1764, 1768, 1769, 1770, 1772, 1773, 1777, 1778, 1781, 1788, 1793, 1798, 1799, 1801, 1803, 1804, 1805, 1807, 1810, 1813, 1816, 1817, 1820, 1823, 1824, 1835, 1836, 1838, 1839, 1840, 1841, 1844, 1845, 1851, 1860, 1863, 1867, 1869, 1879, 1880, 1883, 1884, 1886, 1895, 1897, and 1898 (fifty-eight times).

In all other years between 1700 and 1899 two districts have been active and two districts have been quiescent.

If the seismic activity or quiescence of three large districts out of four in the world is an indication that there has been unusual seismic activity or quiescence in the world generally, then the last two tables may be taken in conjunction with the two first. If we do this we see that, in 131 years out of 200, seismic activity or quiescence has generally been simultaneously in accordance in various parts of the world. In the remaining sixty-nine years the activity of two large districts has been balanced by the quiescence in two other large districts.

V. *Megaseismic Frequency.*

Between 1899 and 1909 the number of very large earthquakes recorded was not less than 976. Many of these were recorded at stations all over the world, others over the whole of the Northern Hemisphere, and none of them disturbed an area less than that of Europe and Asia.



Scale ¾ of the original.

Illustrating the Sixteenth Report on Seismological Investigations.

The numbers recorded in successive months were as follow:—

Year	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total.
1899 .	9	5	9	4	3	6	7	7	12	4	7	4	75
1900 .	7	3	3	2	3	4	2	4	5	6	5	3	47
1901 .	7	4	8	4	4	3	0	8	6	6	11	6	67
1902 .	12	7	9	8	4	2	4	11	8	3	6	3	77
1903 .	10	11	7	4	8	8	5	5	8	9	6	10	91
1904 .	4	2	8	9	5	8	6	8	7	6	5	6	74
1905 .	7	11	10	7	6	8	11	3	7	6	5	5	86
1906 .	14	18	20	11	4	9	5	22	12	10	8	7	140
1907 .	8	4	9	6	12	9	7	7	5	10	10	7	94
1908 .	4	6	11	5	8	4	4	12	9	8	13	6	90
1909 .	9	10	11	14	11	14	8	13	13	15	8	9	135
	91	81	103	74	68	75	59	100	92	83	84	66	976
		275			217			251			233		

Winter months . . 508 } 976
Summer months . . 468 }

VI. *Observations on Tidal Load at Ryde, Isle of Wight.*

By the kind permission of the Committee of the Royal Victoria Yacht Club at Ryde I was allowed to instal an instrument, somewhat similar to the one at Bidston,[1] in one of their cellars. The room, which is about 12 feet below the surface, has a concrete floor. The column to support the instrument is a glazed earthenware drainpipe. At a distance of 138 feet from this on the north side, a sea wall forms the face of an outside veranda. With a spring tide the water rises against this to a height of 5½ feet. The same tide 1,508 feet further to the north, which is low-water mark, the depth of the water is about 12 feet.

From March 4 to April 8 the boom of the pendulum was oriented east-west, so that it recorded tilting of the ground in a north-south direction. It had a period of 15″ and 1° turn of the calibrating screw, which gives an angular deflection of 1″.9, caused the end of the multiplying lever to move 11 mm.; 1 mm. displacement on the photograms is therefore equal to 0″.17 of arc. The average ranges of tide at Ryde are from 9 feet to 13 feet.

A 10-foot tide results in a deflection of 0″.85 of arc. At Bidston a 10-foot tide gives at a distance of two miles a tilt of 0″.2. If the Bidston instrument had been installed within 150 feet of the sea the deflections might have been measurably much larger. One inference is that the rocks forming the bed of the Solent are more yielding than the rocks beneath the Irish Sea at Bidston. See Plate I.

A curious feature in the Ryde photograms is the flatness of many of the crests and hollows of the deflections, which seems to indicate that from time to time the water remains high or remains low for several hours.

On April 8 the instrument was turned through 90°, *i.e.*, the boom

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[1] See *Brit. Assoc. Report*, 1910, p. 49.

was pointed north or towards the advancing and retreating tide; the resulting photograms are practically straight lines.

These observations were discontinued on May 24.

VII. *Tidal Load Experiments in Pennsylvania Railway Tunnels.*

Since 1909 a number of experiments have been made regarding the stability of the Pennsylvania Railway tunnels under the North or Hudson River. The results show that the tunnels rise and fall under the influence of the superincumbent tidal load. A 4.4-foot tide causes a variation in elevation of 0.008 feet.

This was arrived at by sinking a tube in certain instances to a depth of 200 feet through the silt beneath the bed of the tunnel until it reached the solid rock. A 2-inch iron rod passed freely down each of these tubes and was firmly fixed in the rock. The upper end of the rod passed through a stuffing-box on the top of the tube. The assumption made was that the top of this rod remained fixed and relatively to it the bottom of the tunnel rose and fell. This relative movement was recorded by a lever having a multiplication of ten which recorded on a strip of paper. The resulting diagrams have an exceedingly regular character and correspond in time with the records of a tide-gauge which gives the height of water in the river. The tunnels are resting in a quasi-fluid material and show slight depressions by the passing of locomotives. A load passing through the tunnel causes a wave-like action, a point immediately beneath the load being depressed, whilst the point 200 feet in advance of the same rises. I am indebted for this information to Mr. Forgie, Engineer to the North River Division.

VIII. *Experiments in Pits in the Midlands.* By J. J. Shaw.

The experiments commenced at the end of June 1910 by the installation of a horizontal pendulum in a chamber 1,960 feet below ground at the Sandwell Park Colliery, near West Bromwich. The instrument used was similar to the one used at Bidston, but with facilities for obtaining a somewhat higher degree of sensibility. The chamber was lined with several feet of concrete, but unfortunately the traffic of the pit passed within a few feet of it, whilst at a distance of about 100 feet there was a large sump from which water was pumped every night. From the outset it was seen that the strata were ever moving, the movements being partly due to pumping, blasting, and traffic. The direction in which the boom wandered was towards the dip of the strata. Observations were discontinued early in August, and the instrument was removed to a new colliery at Baggeridge, near Dudley, seven miles from its previous position. The instrument was installed at the end of a concrete-lined *cul de sac*, where only occasionally traffic passed, and then never nearer than 100 feet. The depth was 1,800 feet. Pumping took place once a month. The movements were very similar to those at West Bromwich, and there was a tendency for the boom to wander in the direction of the dip. In this instance this was towards the west, whereas at West Bromwich it had been towards the east. The outstanding feature of these experiments is that even at very considerable depths observers will not be immune from continual changes of level. In the early part of this year the rate of the film was changed

from 3 inches per day to 12 inches per hour, the object being to record earthquakes. A few small shocks have been recorded, but up to the present we have not succeeded in recording shocks of any magnitude. Great difficulty is experienced in working underground on account of the saline atmosphere, which causes corrosion. One device tried for keeping the connection between the style on the boom and the multiplying lever was a small pendulum where the bob was a globule of shellac and the suspension was a quartz fibre. This was found to work well and to be of great delicacy.

Our very best thanks are due to the Earl of Dartmouth for granting permission to work in the mine, and also to Councillors H. W. Hughes, F.G.S., and Ivor Morgan for rendering valuable assistance in carrying out these experiments.

IX. *List of Strong Shocks in the United States and Dependencies.*

By Professor H. F. REID.

The dates of the shocks between 1663 and 1737 are corrected so as to give them according to the present method of reckoning, which began in 1752.

Abbreviations.

B = Brighams' Catalogue, 'Memoirs of Boston Soc. of Nat. History,' vol. ii.; 'Note Additionelle,' by A. Lancaster.
H = Holden's Catalogue, 'Smithsonian Miscellaneous Collection,' 1887.
R = Rockwood's Lists in the 'American Journal of Science.'
P = Catalogues by Alexis Perrey. Also see Deckert's paper in the 'Gesellschaft für Erdkunde,' Berlin, 1902.
S = Stewart's Catalogue (manuscript).
M = Martin's List (manuscript).
McA = McAdie's Catalogue, 'Smithsonian Miscellaneous Collection,' part of vol. xlix.
I = An intensity sufficient to damage walls and chimneys.
II = " " to destroy a few buildings.
III = " which has resulted in widespread disaster (see British Association Report, 1908, p. 78).

Date	Place	Intensity	Remarks
1663 Feb. 5 .	New England States	I	Three violent shocks. (B., p. 3.)
1727 Nov. 8 10.40 P.M.	Newbury, Massachusetts	I	(B., p. 7.)
1732 Sept. 15 noon	Newbury, Massachusetts	II	Also felt at Boston. Strongest apparently in Montreal. (B., p. 8.)
1737 Dec. 17 11 P.M.	New York .	I	Severe enough to throw down chimneys. Felt in Boston and other places. (B., p. 9.)
1786 . .	Pavloff, Alaska	III	With volcanic eruption. (H., p. 31.)
1790 (?) . .	Inyo County, Cal.	III	Indians state that a shock similar to that of March 26, 1872, occurred about eighty years earlier. (H., p. 31.)
1806 March 24, midnight	Santa Barbara, California	I	Church walls cracked. (H., p. 32.)
1811–1813	New Madrid, Missouri	III	(References.—W. J. McGee, *Bull. G.S.A.*, 1892, iv., 411–414; G. C. Broadhead, 'The New Madrid Earthquake,' *Am. Geol.*, 1902, xxx., 76–87; W. J. McGee,

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
			'The New Madrid Earthquake,' *Am. Geol.*, xxx., 200–201; Edw. M. Sheppard, 'The New Madrid Earthquake,' *Jour. Geol.*, 1905, xiii., 45–62.)
1812	Atka, Alaska	III	(H., p. 32.)
1812 May	Southern California	I	Continual shocks for 4½ months. (H., p. 32.)
1812 Oct. 8, 7 to 8 A.M.	Santa Barbara, Cal. San Juan Capistrano, Cal.	II–III	(H., pp. 32, 33.)
1812 Oct. 21	San Juan, Capistrano, Cal.	II	(H., p. 33.)
1812 Dec. 8	From San Diego to Purisima, Cal.	I	At San Gabriel, church badly cracked. (H., p. 33.)
1812 Dec. 21	San Fernando, Cal.	I	(H., p. 33.)
1813 or 1815	Santa Clara Valley (?), Cal.	II	(H., p. 33.)
1817 Oct. 5	Woburn, Massachusetts	I	(B., p. 17.)
1836 April 2	Pribyloff Islands, Alaska	III	(H., p. 34.)
1836 Aug.	Pribyloff Islands, Alaska	III	(H., p. 36.)
1843 Feb. 8	West Indies	III	Guadaloupe and Pointe Petre wholly destroyed. More than 5,000 people killed. Distinctly felt in various parts of the United States. (R., *A.J.S.*, xliv., p. 419.)
1847	Alaskan Coast, Alaska	II prob	General earthquake, very severe at Sitka. (W. H. Dall, 'Alaska and its Resources,' p. 342.)
1849 Oct. 22	Commander Islands, Alaska	II–III	Violent earthquake lasting all night. (P.)
1849	S.W. Guam	II	(Reference: Peterm, *Mitt.*, 1905, li., p. 40.)
1852 Nov. 9	Fort Yuma, Arizona	I or II	The shocks continued almost daily for many months. (H., p. 38.)
1857 Jan. 8 and 9	Southern California	III	Due to displacement of the San Andreas fault in Southern California for a length of 225 miles. (See *Rep. Cal. Eq. Com.*, vol. i., pt. 2, pp. 449–451.) (H., pp. 48, 49.)
1865 Oct. 8, 12.45	San Francisco, California	II	Two violent shocks within half a minute. The accounts from Sacramento, Stockton, and San José represent the earthquake as the severest ever felt in those cities. Ten or eleven distinct shocks were felt after the first shaking up to 5 A.M. of the 9th. (See *Rep. Cal. Eq. Com.*, vol. i., pt. 2, pp. 448–449.) (H., pp. 65, 66, and R., xl., p. 366.)
1866	Wamego, Kansas	I	(H., pp. 76–80.)

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
1868 Oct. 21, 7.50 A.M.	San Francisco and neighbourhood, California	III	Due to movement on the Haywards fault, east of San Francisco Bay. At the corner of Market and First Streets, San Francisco, the ground opened several inches wide for a distance of forty to fifty feet. The earthquake was severe in the interior. Felt at Sacramento and Stockton; at Redwood City, where the court-house was wrecked; Marysville, Grass Valley, and Sonora also felt the shock. (See *Rep. Cal. Eq. Com.*, vol. i., pt. 2, pp. 434–448.) (R., xlvi., p. 428.)
1869 Oct. 22, 6 A.M.?	All over New England States	—	With an intensity of III. at Fredericktown, New Brunswick. (B., p. 22.)
1869 Dec. 27, 2.10 A.M.	Sacramento, California	II	(H., p. 84.)
	Marysville, Cal.	I	—
1872 March 26	Inyo County, California	III	Movement on fault. (See Holt's book.) (H., pp. 88–92.)
1872 Dec. 10, 4.30 P.M.	Helena and Deer Lodge, Mont.	I	Two shocks of five seconds' duration, direction West to East. (R., v., p. 262.)
1875 Dec., 8–9 P.M.	Porto Rico	I–II	Town of Arecibo nearly destroyed. (N.W. Porto Rico). (R., xii., p. 29.)
1877 Oct. 12, 1.53 P.M.	Portland, Oregon	I	Two shocks. (R., xv., p. 25; H., p. 100.)
1878 Aug. 29	Makuslin, Alaska	I	Town reported destroyed. (R., xvii., p. 16.)
1881 April 10, 2.05 to 2.10 A.M.	Santa Clara Valley and Valley of California	I	The centre seems to be in San Joaquin County; VII–VIII at Modesto; VI–VII at Stockton; VI at Merced; VI at Ione City; III–IV at Visalia. In the Santa Clara Valley, VI; at Hollister, VI; V at Salinas, Centerville, San Jose; IV at San Francisco. There may have been two centres of disturbance, one near Modesto and one near Hollister. Felt probably over an area of 15,000 square miles. (S.)
1882 Sept. 7	Panama, C.A.	I–II	Shocks continued for three or four weeks. (S.)
1886 Aug. 31, E.S.T., 9.51.06 P.M.	Charlestown and Summerville, S.C.	III	See Ninth Annual Report U.S. Geol. Survey. (Dutton.)
1889 July 19	Memphis, Tenn.	I	—
1894 July 18, M.S.T., 3.50 P.M.	Ogden, Utah	I (?)	(H., p. 228.)
1896 May	Orca, Alaska	II (?)	Very severe. (M.)
1898 March 30, P.S.T. 11.42.15 P.M.	Mare Island, Cal.	I	(McA., pp. 11–12.)

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
1899 Sept. 3 to 10; Sept. 10 to 17	Yakutat Bay, Alaska	III	(References.—*Nat. Geog. Mag.*, x., 421; Tarr, 'Recent Changes in Alaska,' *Geog. Jour.*, 1906, pp. 30–43; L. Martin is publishing a *U.S.G.S. Bull.* on these earthquakes, 1910.) Felt from Lynn Canal to Aleutian Islands. Some islands said to have settled 20 to 25 feet. Strongest shock on September 10. The 'Bonanza' passed between Amukhta and Yumaska Islands (Aleutian Islands) on September 17; both islands are volcanic cones and great clouds of smoke were issuing from both.
1899 Dec. 25, 4.29 A.M.	Santa Jacinto, Riverside Co., S. California	I	Shocks continued. Thirty on 25th day, others on the 26th day. Felt from San Diego, California, to Seligman, Arizona.
1900 Oct. 9	Prince William Sound, Alaska	III	Felt over an area of 121,000 square miles on land. (M.)
1901 Dec. 30–31	Kenai, on Cook Inlet, Alaska	III (?)	A strong volcanic eruption. Earthquake which accompanied it caused several tidal waves.
1902 July 27, 11 P.M., to 31	Los Alamos, Cal., and neighbourhood	I	—
1902 Sept. 22	Guam	II–III	(*Peterm., Mitt.*, 1905, li., p. 40). 180 shocks experienced in 24 hours.
1902 Nov. 17, M.S.T. 12.53 P.M.	Washington Co. S.W. Utah	I	—
1905 Dec. 23, P.S.T., 2.23 P.M.	Bakersfield, California	I or less.	Three shocks.
1906 Jan. 25, M.S.T., 1.32.30 P.M.	Flagstaff, Arizona	I	Duration 20 sec. Probably in San Francisco mountains, north of Flagstaff.
6.36.7 P.M. 7.31 P.M.	. . . .	. .	After-shocks.
1906 April 18, P.S.T., 5.11.58 A.M.	Along coast of California	III	Disastrous shock which destroyed San Francisco and did serious damage in many other cities. The earthquake was caused by a movement on the San Andreas fault for a length of 270 miles. Many after-shocks. (See *Rep. Cal. Eq. Com.*)
1906 April 18, P.S.T., 4.26 P.M.	Brawley, S.E. California	I	Duration 10 sec. Probably felt over an area of 30,000 square miles.
1906 July 12, M.S.T., 5.15 A.M.	Socorro, New Mexico	I	Many shocks between July 2, 1906, and end of year. Probably felt over 60,000 square miles.
1906 July 16, M.S.T., 12 noon	Socorro, New Mexico.	I	Probably felt over 60,000 square miles.

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
1906 Sept. 27, 10.47 A.M. (14.41.30 G.M.T.)	San Juan, Porto Rico, Santo Domingo, and St. Thomas	I	Duration 30 sec. Shock general throughout Porto Rico. Felt for a distance of 300 to 350 miles. Probably central near San Juan. (P.R.)
1906 Nov. 15, M.S.T., 5.15 A.M.	Socorro, New Mexico	I	This was the severest of a long series of shocks which began on July 2 and lasted seven or more months. Probably felt over an area of 100,000 square miles.
1908 Feb. 14 .	Prince William Sound, Alaska	II (?)	Cables broken in Valdez Fiord. Recorded at distant seismograph stations (M.)
1908 May 14, 11 P.M. ± (8.32.00, ± May 15, G.M.T.)	Near Yakataga, Alaska	II (?)	—
1908 Aug. 18, 2.59 A.M. 3.08 A.M. 5.27 A.M.	Eureka, California	I	Area of the shock probably not more than 200 or 300 square miles. First shock did all the damage.
1909 Oct. 28, P.S.T., 10.48 P.M.	N.W. California and S.W. Oregon	I	Duration 22 sec. The centre of the shock was near Fortuna, Humboldt Co., Cal. (near Eureka), where chimneys were thrown down and much plate-glass broken. At Ferndale and Eureka the shock was nearly as strong. Probably felt over an area of 250,000 to 300,000 square miles on land. Probably due to a slip on a fault near Fortuna.
1909 Oct. to Dec.	North of Great Salt Lake, Utah	I	Thirty or sixty shocks reported from the old lake deposits just north of the present Great Salt Lake.
1909 Dec. 10, Local time, 9.10 A.M	Agano, Guam .	II	Two shocks, duration 22 sec. This was a heavy shock and did very serious damage to buildings in Agano. Small fissures were made in the ground and water spouted out in places. These were near high-water mark and were undoubtedly due to slumping and vibrations. Surface waves were also seen. Recorded at Manila at 23.33.9 and at Honolulu at 23.29.7 G.M.T. This would put the time at the origin, supposed close to Agano, about 23.30 G.M.T.

X. *List of Destructive Earthquakes which have occurred in Peru and North Chile.* By H. HOPE-JONES, Esq., *Lima.*

All entries in this list are, with the exception of eight, additional to those found in the provisional list by Count Montessus de Ballore

(see British Association Report, 1910, pp. 69-71). Where dates have differed in these two lists those given by the latter author are placed in brackets. The meaning of intensities given by the numerals I, II, and III are explained on p. 47.

Date		Classification	Approximate Epicentre
1578	June 17	II	Lima
1582	January 22 (January 16)	III	Arequipa
1582	July 2	III	„
1586	July 9	III	Lima
1590	?	III	Camaná
1604	November 23 (November 24)	III	Arequipa
1609	October 19	II	Lima
1619	February 16	III	Trujillo
1630	November 27	II	Lima
1647	May 13	III	C. Chile (?)
1650	March 31	III	Cuzco
1650	March 31	III	Lima
1655	November 13	III	„
1658	February 14	III	Trujillo
1664	May 12	II	Ica
1687	October 20	III	Lima
1699	July 14	I	„
1716	February 6	I	Torata
1725	January 6 (January 8)	III	Ancash
1725	March 27	III	Camaná
1746	October 28	III	Lima
1747	?	I	Carabaya
1777	January 26	I	Lima
1784	May 13	III	Arequipa
1794	March 26	I	Lima
1806	December 1	I	„
1813	March 30	II	Ica
1814	February 1	I	Piura
1821	July 10	III	Arequipa
1828	March 30	II	Lima
1831	October 8	II	Arequipa
1833	September 18 (October 18)	II	C. Tacna
1839	June 10	I	Ica
1857	August 20	I	Piura
1860	April 18	I	Arequipa
1860	April 22	I	Lima
1861	April 13	I	Andahuailas
1868	August 13	III	Arica
1869	August 24	II	Pica
1869	November 3	I	Arequipa
1871	February 22	I	Puno
1871	August 2	I	Arequipa
1871	October 5	I	C. Iquique
1872	January 10	I	Arequipa
1873	June 10	I	„
1875	April 5	I	Trujillo
1875	December 5	I	Abancay
1877	May 9	III	C. Arica
1878	January 25 (January 23)	I	C. Iquique
1883	October 1	I	Arequipa
1897	September 20 (September 23)	I	Matucana
1898	June 20	I	Ica

XI. *Unpublished Notes relating to Destructive Earthquakes.*

On February 25, 1897, on behalf of the Seismological Committee, I approached the Under-Secretaries of State for Foreign and Colonial Affairs with the object of obtaining their assistance in the compilation of a list of destructive earthquakes. On April 10 a similar application was made to the India Office. These applications received favourable consideration, and a letter, of which the following is a copy, was forwarded to his Majesty's Representatives in certain Foreign Countries, English Colonies, and Dependencies:—

> SIR,—At the present time there exists no complete list of the destructive earthquakes which have occurred in various parts of the world, but portions of such a list are now being compiled by the Seismological Committee of the British Association for the Advancement of Science, but the information is defective as to many countries. It is desired, therefore, to obtain such a register giving the dates and places of origin of earthquakes which have produced structural damage in the country in which you have the honour of representing his Majesty's Government. In the list of earthquakes which it is hoped you may be the means of obtaining, the numerals I, II, and III should be attached to each entry. No. I should refer to those shocks which have shattered a few structures. No. II should be attached to those which have destroyed structures in a limited area. No. III to those which have caused destruction over a large area.
>
> As the records of small earthquakes are not required, the list we ask for will in most instances be short. In some countries such a list may already exist in print.
>
> The objects in view are threefold. First, to provide material for scientific analysis; second, to determine the frequency of destructive disturbances in various countries; and third, to map out areas where special precautions should be taken with regard to construction.
>
> I trust you will find it possible to co-operate in the collection of this material, which will possess not only scientific but also practical utility.—I remain, Sir, on behalf of the Committee, your obedient servant,
>
> JOHN MILNE,
> Hon. Secretary Seismological Committee of the British Association.

The following notes are a *résumé* of the replies which have been received to this letter. In many instances printed matter, as for example the Proceedings of learned societies, special works, official documents, were sent to Shide. As these are in nearly all cases accessible to those who desire to see them, I only refer to them by name. So far as possible the earthquakes referred to are those not included in the 'General Catalogue of Destructive Earthquakes.' The countries are arranged alphabetically.

Abyssinia.—Lord Herbert Hervey, Hon. Chargé d'Affaires, reports that no records have been kept so far as he has been able to ascertain. Earthquakes which have taken place in recent times have ben insignificant, and not of sufficient force to bring them within categories I, II, or III.

West Australia.—The Governor, H.E. Sir Gerald Strickland, reports that no destructive earthquake has been experienced in Western Australia.

South Australia.—The Government Astronomer, G. F. Dodwell, reports on two earthquakes, May 10, 1897, Class II, origin submarine and not far from Kingston and Beachport. At Kingston, Robe, and Beachport walls and chimneys were thrown down; slight damage

extended within a radius of about 250 miles from the origin. September 19, 1902, Class 1, origin near Kangaroo Island. Some houses at Warooka were wrecked, walls were cracked within a radius of one to two hundred miles. Both earthquakes were considered due to fault lines running north and south from Lake Torrens through Spencers and St. Vincent Gulfs. A pamphlet on South Australian earthquakes is in course of publication.

Queensland.—The Hon. Sir Arthur Morgan, Lieut.-Governor, reports that no records have been kept; and for the last thirty-two years at least Mr. J. B. Henderson says that Queensland has been singularly free from such disturbances.

Victoria.—Sir T. D. Gibson Carmichael writes that the Government Astronomer is collecting information, which, when completed, will be sent to Professor John Milne at Shide.

New South Wales.—The Hon. G. B. Simpson reports that, so far as State records show, no earthquake of sufficient severity to cause damage has been experienced in New South Wales.

Tasmania.—H.E. Major-General Sir Harry Barron writes that he is informed by the Premier that no destructive earthquakes have occurred in Tasmania within the memory of man.

Canada.—The Secretary of State for External Affairs, the Hon. Charles Murphy, says that the earthquake of 1663, which was felt throughout the St. Lawrence Valley, was destructive. The earthquake of October 1870 did slight damage to chimneys and ceilings, especially at Baie St. Paul, on the north shore of St. Lawrence below Quebec.

Cape of Good Hope.—The Rt. Hon. Sir W. F. F. Hely-Hutchinson forwards two minutes from Ministers, but no earthquakes are reported.

Ceylon.—Sir H. E. McCallum says that so far as can be ascertained there are no records of destructive earthquakes in Ceylon. Slight shocks have stopped clocks and produced cracks in one or two houses.

Cyprus.—Sir C. A. King-Harman states that although slight shocks of earthquakes have occasionally been experienced, nothing of a destructive nature has occurred since the British occupation.

Chile.—H.E. H. C. Lowther writes that the Director of the Seismological Department is compiling a catalogue of earthquakes in Chile. A provisional list of destructive earthquakes which have occurred in the Southern Andes south of latitude 16, by Count de Montessus de Ballore, will be found in British Association Report, 1910.

China.—Sir John N. Jordan sends 'Catalogue des Tremblements de Terre Signalés en Chine d'après les Sources Chinoises, 1767 B.C. to 1895 A.D.,' par Le R. P. Pierre Hoang. A translation of extracts from the 'Shun T'ien Fu Gazeteer,' which gives a list of earthquakes from 1665 to 1883; a list of earthquakes in 1882. This is attached to a paper by Dr. Macgowan, see 'China Review,' vol. 14, pp. 147-150. All this information will be incorporated in a catalogue of destructive earthquakes published by the British Association. This is now in the press.

Colombia.—H.E. the British Minister, Francis W. Stronge, very kindly forwarded a list, obtained from the Columbian Minister for Foreign Affairs, of severe earthquakes felt in that Republic between 1625

and 1910. With the exception of the two following these have been incorporated in the 'Catalogue of Destructive Earthquakes': 1906, January 31, 10 A.M., the following towns were destroyed: Bocagrande, Cape Manglares, Puerto Limones, Salahonda, Las Baras, Trujillo, and Chagal. 1910, March 30 and 31 and April 1, great landslides at Sutamarchin in Boyaca.

Costa Rica.—Consul F. N. Cox sent a detailed account of the earthquake of April 12-13, 1910. Shocks commenced April 13, 12.37 A.M. or 6.13 G.M.T. The greatest damage was done at 1.5 A.M. or 6.41 G.M.T., and at 8.30 A.M. or 14.6 G.M.T., on April 14. The hypo-centre was south-west of Cartago, which, with San José and many villages, suffered great damage. On May 4, 6.50 P.M., or May 5, 0.26 G.M.T., Cartago, Paraiso, and surrounding hamlets again suffered. The shock was felt in all parts of the Republic and also in Bocas del Toro.

Denmark.—The First Secretary of the British Legation, Mr. J. C. T. Vaughan, forwarded an account of two earthquakes which occurred in 1837 and 1867 in the island of St. Thomas (see St. Thomas).

Egypt.—Councillor R. W. Graham sends notes on the following three earthquakes: 1847, a minaret was thrown down in Cairo; 1887, Suakin on the Nile Valley was disturbed, houses in Cairo damaged; 1906, December 26, the Nile Valley and the Red Sea coast were shaken, the lighthouses of Shadwan and Ashrafi in the Red Sea were damaged; origin probably about 26° N. lat. The intensity of these shocks was of the order No. I.

Fiji.—The Hon. Charles Major reports that no seismological records have been kept in Fiji, and beyond ordinary slight shocks no serious earthquakes have been known to occur in the Colony.

France.—The Hon. L. D. Carnegie sends a note for Monsieur Pichon which refers to three earthquakes felt in 1889. The first of these occurred on June 11, in the Departement des Bouches du Rhône; destruction occurred within an area of 360 kilometres square. The second occurred on June 23, in the Departement Vendée; no damage. The last took place on August 5, in Bretagne, and was felt throughout Finistère; the damage was small.

Gambia.—The Governor reports that no earthquakes have been recorded.

Gilbert and Ellice Islands.—The Resident Commissioner writes that earthquakes appear to be unknown in that Protectorate.

Gold Coast.—H.E. Sir J. P. Rodger sends a Report of a destructive earthquake which occurred at Accra in 1862; Christiansborg Castle was laid in ruins. This was on July 10. In Jamestown all the stone houses were entirely overthrown.

Greece.—Sir F. E. Hugh Elliot transmits a list prepared from the records at the Observatory at Athens of destructive earthquakes in Greece from 1893 to November 1909. Those which are not in the 'Catalogue of Destructive Earthquakes' are as follow: 1909, June 15, 23.26 G.M.T., at Lamia and Domoko, some walls were cracked. 1903, August 11, 4.37 G.M.T., at Cythera, the village of Mytata was destroyed; opposite Biaradika the ground was cracked for 200 metres; at Cythera and Potamos houses were rendered uninhabitable.

1909, May 30, at Vitrinitsa (Doris), at 6.15, the village of Douvia was destroyed, houses damaged at Vitrinitsa and Palaioscarion, Galaxidi and Itea. 1905, January 20, at Aghuia, at 2.32, destroyed houses in the villages of Aramidi, Sklethron, and Canalia. 1909, July 15, at Amalias (Elis), at 0.35, the villages of Amalias, Havari, Sinoti, Lopesi, Bouchioti, Calyria, &c., were overthrown.

Guatemala.—H.E. British Minister, L. E. G. Carden, forwards a list of earthquakes in Guatemala City. Those not in the 'Catalogue' are: 1902, April 19, 2 A.M., great destruction in Quezaltenango, also in Guatemala City. 1907, September 24, 10 A.M., damaged building in Guatemala City.

British Guiana.—H.E. Sir F. M. Hodgson reports that no destructive earthquakes have taken place in Demerara, but slight earth tremors have been felt from time to time.

Honduras.—Through H.E. L. E. G. Carden, Esq., brief notes are sent relating to violent shocks on January 20-23, 1835, and slight shocks which did some damage to buildings in 1897, 1899, and 1902. They occurred in the north-west and centre of Honduras, and coincided with similar movements in Guatemala and Salvador. The Republic of Honduras, as a whole, is free from earthquakes.

Iceland.—Sir Allan Johnstone sends with a translation a copy of Thoroddsen's 'Icelandic Earthquakes' ('Landskjalfar A Islandieftir,' Thorvald Thoroddsen, Copenhagen, 1899 and 1905).

India.—Through the India Office we received lists of destructive earthquakes published by the Asiatic Society of Bengal and the Geological Survey of India.

Kashgar.—His Majesty's Consul, Mr. George Macartney, in Kashgar sends extracts from his diaries relating to the following disturbances: 1902, August 22, 8 A.M. (2.56 G.M.T.), buildings much damaged, the village of Artush destroyed, there were many after-shocks; the most severe of these occurred on August 24, 26, and 30, September 1 and 2, about 10 P.M. or 4.56 G.M.T.

Loanda.—Mr. Consul H. C. Mackie says that on February 27, at 2 P.M. (local time), there was an appreciable earthquake shock at Benguella.

Malta.—H.E. Gen. Sir H. M. L. Rundle forwards a list of seven destructive earthquakes which have been noted in Malta. These are all included in the 'General Catalogue.'

Malay States.—The High Commissioner of the Malay States reports that there are no records of destructive earthquakes.

Mauritius.—Mr. J. Middleton, Assistant Colonial Secretary, states that there is no record of any destructive earthquake ever having occurred at Mauritius.

Mexico.—H.E. Reginald T. Tower, C.V.O., sends a voluminous report in Spanish which was drawn up by the Geological Institute; with the exception of the following all the entries relating to destructive earthquakes will be found in the 'General Catalogue': 1900, January 19, 11.45 P.M. local time, strong in Colima, buildings suffered much, particularly the cathedral; damage was also done in Ejulta, Jalisco, Michoacan, Guerrero, and other places. 1902, January 16, 5.19 P.M.

local, Chilpancingo, Chilapa, and Tixtla, and over all the south of the Republic and in Guatemala. 1905, May 9, 0.8 A.M. local, severe in Autlan, in Jalisco, and felt throughout the Central States. 1907, April, 14, many houses destroyed in Guerrero; it was felt in Mexico City at 11.31, 10 P.M. local, the epicentre was at San Marcos. 1908, March 26, much destruction at Ometepec in the State of Guerrero, felt all over the south of the Republic; it was recorded in Mexico City at 9.12 P.M. (March 27, 3.48.5 G.M.T.). 1909, July 30, Mexico time 4.15.57 A.M. (10.52.27 G.M.T.), epicentre near Acapulco, where many houses were destroyed and the sea retreated from the coast. Destruction also occurred at San Marcos and Chilpancingo; extending over an area 435 by 310 miles.

Montenegro.—Mr. W. O'Reilly states that there is no record or recollection of a destructive earthquake in the Principality.

Morocco.—Mr. W. F. Rattigan writes that within the memory of the oldest inhabitant nothing beyond shocks of the very slightest nature have been felt, and so far as it is possible to ascertain no violent earthquake has occurred in Morocco in historic times.

Natal.—The Hon. Sir Henry Bale reports that earthquakes are very exceptional in Natal and in every recorded case have been very slight.

Nigeria.—The Acting Colonial Secretary states that in this colony and protectorate so far as is known earthquakes have not occurred.

New Guinea, Papua.—Through the Rt. Hon. the Earl of Dudley and the Acting Prime Minister of the Commonwealth of Australia we learn that so far as can be ascertained there is no record of any destructive earthquake in Papua except the one at Buna Bay on October 2, 1906. This took place at 11.35 A.M. (local time); the shaking lasted three minutes and was accompanied by heavy sea waves. Slight tremors are felt throughout the territory six or seven times per year.

Nyasaland.—Sir Alfred Sharpe states that no destructive earthquakes have occurred since the Protectorate has been known to Europeans. Mild shocks are felt from time to time on the north and west shores of Lake Nyasa. To the north of this lake there is a volcanic district, with crater lakes and many hot springs. Earthquakes occurred at Zomba on June 6 and 7, 1910. The one on June 6 took place at 22.23 and was pronounced, but there was no damage.

New Hebrides.—The Resident Commissioner reports that earth tremors are frequent, but no shocks have been felt since his arrival in November 1907.

New Zealand.—H.E. Rt. Hon. Lord Plunket forwards a list of destructive earthquakes by Mr. G. Hogben. These will be found in the 'Transactions of the New Zealand Institute,' vols. 37 and 38. The one on August 9, 1904, originated at 22.49 G.M.T., 179° E. long., 42° S. lat. Others of importance which are not included in the 'Catalogue' occurred on November 16, 1901, and on July 29, August 9, and September 8, 1904.

Norway.—A short list, prepared by Dr. Carl Fred. Kolderup, has been forwarded to us by Mr. T. J. Wingfield. One on October 23, 1904, destroyed many chimneys in the Prefectures of Smaalenene, Jarlsberg and Larvik, also in Bratsberg and Buskerud.

Palestine.—Consul E. C. Blech has forwarded a list of earthquake shocks felt at Jerusalem since 1864. These were extracted from records kept at the Hospital of the London Jews Society in Jerusalem. One which took place at 2 A.M. local time, January 5, 1900, and another which occurred on March 31, 1903, at 12.45 A.M. local time, are not included in our 'Catalogue'; the latter damaged buildings in Jerusalem.

Panama.—The Minister Resident, Claude C. Mallet, sends a short list of earthquakes which have caused damage in this Republic. Slight shocks occurred on July 7, August 17, 1908, May 3, July 28, August 28 and 30, 1909, but these were not of a serious nature.

Paraguay.—Mr. G. W. E. Griffith states that no records exist to show that any destruction to property has ever been caused by earthquakes in this Republic.

Persia.—H.E. Sir G. Barclay sends a report of two earthquakes which occurred in the Kerman district: April 18, 1911, 9.52 P.M. or 5.22 G.M.T., a shock damaged a few buildings in Kerman; March 28, 1911, also at 5.22 P M. G.M.T., but it did not cause damage.

Peru.—Consul-General Lucien J. Jerome forwards a list of earthquakes compiled by Mr. Hope Jones, a member of the Geographical Society of Lima. See this Report.

Rumania.—Sir W. Conyngham Greene forwards a pamphlet published by the Astronomical and Meteorological Society of Bucharest on 'Mouvements Sismiques en Roumanie pendant la periode 1907-1909.' Mr. R. J. Hamilton forwards a number of pamphlets from the 'Annales de l'Institute Meteorologique' containing lists of earthquakes for the years 1891-1908.

Salvador.—The British Minister, L. E. G. Carden, sends a list of earthquakes compiled by the Director of the National Observatory of San Salvador. The following are not included in our 'General Catalogue': July 19, 1906, had an intensity corresponding to No. VII on the Rossi-Forel scale. In May and June 1909 slight shocks were felt, and again in October 1910.

Servia.—The British Minister, Sir James B. Whitehead, forwards a list of destructive earthquakes prepared by the Geological Institute of the University in Belgrade, covering the period 1755-1905 inclusive. The following are not included in our 'Catalogue': January 30, 1902, at Mostanica, Ristovac, Vranje, and Vranjska Banja; these places were also shaken on April 4 and 10, 1904. On January 6, 1905, and July 24, 1906, places lying between 44° 22′ and 44° 32′ N. lat. and 19° 21′ and 19° 29′ E. long were severely shaken. On May 13, 1905, the district 43° 41′ to 43° 44′ N. lat. and 21° 46′ to 21° 54′ E. long. suffered.

Siam.—Consul W. R. D. Beckett transmits a copy of a note which he has received from his Royal Highness Prince Devawongse to the effect that seismic disturbances in Siam have been very few in number, and in no instance have they been violent enough to destroy or damage buildings.

Sierra Leone.—The Acting Colonial Secretary writes that there is no record of any destructive earthquake in the history of the colony.

In another note Lieut. H. C. Lukach refers to a slight earthquake which occurred at Freetown on July 28, 1897, at 11 A.M.

Solomon Islands.—The High Commissioner for the Western Pacific understands that earthquakes are of frequent occurrence in the western part of the group. They are all of a slight nature.

St. Helena.—H.E. Lieut.-Colonel Sir H. L. Gallwey writes that there is no record of a destructive earthquake ever having taken place in St. Helena since the island was discovered. The only records of earthquakes refer to the years 1756, 1780, 1817, and 1864, but no damage occurred.

Straits Settlements.—The Colonial Secretary writes that no destructive earthquakes have occurred in the Straits Settlements during the last twenty years.

Spain.—H.E. Rt. Hon. Sir M. W. de Bunsen says that a list of Spanish earthquakes is being collated and will be forwarded in due course.

Tonga, or Friendly Islands.—The Agent and Consul for Tonga states that no records have been kept of earthquakes, and that no destructive earthquakes have been experienced within the group except at the volcanic island of Niafoou.

Tripoli.—The Acting Consul-General, Alfred Dickson, states that, with the exception of feeble shocks at wide intervals, Tripoli has not been visited by any earthquake which can be classed under the Nos. I, II, or III of the circular of the British Association.

Tunis.—Consul-General E. J. L. Berkeley reports that after full inquiry he cannot hear of any records of earthquakes in this region. There has, however, been once or twice extremely slight seismic disturbances.

Uganda.—Mr. W. A. Russell says there are no records of any earthquakes such as are mentioned in the British Association circular.

Uruguay.—Mr. Ernest Scott states that he is informed by the Director of the National Physical and Climatological Observatory at Montevideo that the Republic of Uruguay is not disturbed by local earthquakes, although shocks of some severity have occasionally been felt, presumably caused by vibrations in the Andes Range or other distant localities. Professor Luis Morandi has kindly undertaken to prepare a memorandum which he thinks may interest the Seismological Committee of the British Association.

Venezuela.—Sir Vincent Corbett forwards a list of the principal earthquakes which have occurred in Venezuela since the middle of the nineteenth century. This was compiled by the Director of the Observatory in Caracas. It only contains one reference which is not in our 'General Catalogue.' This occurred on October 29, 1900. The districts affected were situated from 40 to 100 kilometres east of Caracas, which suffered but slightly. Destruction also occurred in Guarenas, Guatire, Rio Chico, Higuerote, and in Macuto.

West Indies: Antigua.—Mr. H. A. Tempany reports on destructive earthquakes in April 1690 and 1833; February 8, 1843. Since 1889 records of earthquakes have been kept. May 29, 1895, shocks were felt in Antigua, St. Kitts, Montserrat, and Barbuda, where

slight damage occurred. April 29, 1897, shocks felt at Antigua, St. Kitts, Dominica, and Guadeloupe, where considerable damage was done to buildings. December to January 1897-98 and September and October 1900, shocks of some intensity occurred in Montserrat and slight shocks were frequent in Antigua. December 3, 1906, in Antigua, and as far south as Barbados, slight damage occurred to buildings in most islands.

Bahamas.—Commissioner P. W. B. Armbrister says that no destructive earthquakes have occurred at Inagua since 1896. In September 1887, however, in two or three weeks shocks were felt nearly every day. They were preceded by rumblings which came from the south. Boundary walls and a few old buildings were thrown down; a considerable number of stone buildings were slightly cracked. It was at this time that the city of Port de Paix, Haiti, was partly destroyed. The Inspector of Lighthouses, Mr. F. J. Lobb, reports that earthquakes were experienced on September 23, 24, 25, and 26, 1887, at the following lighthouses: Inagua, Castle Island, Bird Rock, and Watling Island. One on September 23 at 7 A.M. and 8.10 P.M. local time was the most severe, and caused trifling damage.

Barbados.—H.E. the Governor reports that there are no records of destructive earthquakes.

Bermuda.—The Governor, Lieut.-Gen. Walter Kitchener, reports that no earthquake has occurred in Bermuda coming under the heading of the Circular of the Seismological Committee since the settlement of the colony in 1612.

Dominica.—The Hon. W. H. Porter says that during his forty years' experience of the island he only recollects one earthquake of any force. This occurred between four and six years ago. It exerted its greatest force in the northern half of the island, where a masonry chimney was wrenched. At the other extremity of the island the walls of a village church were slightly damaged. Shocks are felt with greater frequency in the northern and eastern district than to the south and west of the central mountain chain.

Grenada.—The Colonial Secretary, E. R. Drayton, sends an extract from the history section of the Grenada handbook referring to severe earthquakes in 1766, November 18, 1867, and January 10, 1888.

Hayti.—Consul-General Alex. P. Murray sends a short description of destructive earthquakes which occurred in 1564, 1770, May 7, 1842, September 23, 1887. The frequent slight earthquake shocks at Port-au-Prince are generally preceded by a subterranean noise which approaches from the plains and passes beneath the town. No movement of the earth is perceptible. The Haytians call it 'le gouffre,' or 'le bruit de gouffre.'

Montserrat.—Lieut.-Colonel W. B. Davidson-Houston states that, with the exception of the earthquake of February 8, 1843, there do not appear to have been any earthquakes of a serious nature within recent years. In 1896-7-8-9, and again in 1901-2-3, there were numerous slight shocks, but none of these did more than very slight damage, although their frequency made them very alarming. A copy of President Baynes' speech to the Montserrat Legislature on the subject of the earthquake of 1843 was enclosed.

St. Christopher (*St. Kitts and Nevis*).—The administrator, Mr. T. Lawrence Roxburgh, only reports on one destructive earthquake, viz., that which took place on February 8, 1843.

St. Croix.—The First Secretary of the Legation in Copenhagen, Mr. C. T. Vaughan, states on the authority of M. Erik Scavenius that when the island of St. Thomas suffered on November 18, 1867, the neighbouring island, St. Croix, was left almost intact.

St. Lucia—The Administrator refers to the earthquakes of January 11, 1839, which damaged buildings in Castries; that of February 8, 1843; and, lastly, that of February 16, 1906, which also did considerable damage in Castries.

St. Thomas.—This island was badly shaken on August 2, 1837, and again on November 18, 1867 (see St. Croix).

St. Vincent.—The Agricultural Superintendent does not think that St. Vincent has experienced any destructive earthquake since historic times, and from an inspection of old forts and buildings he considers this statement corroborated. Of course, there are many slight shocks.

Tortola.—Commissioner Leslie Jarvis, after a careful and long search among records of this Presidency, states that the only reference to an earthquake which he has come across is that of November 18, 1867. Reports on this earthquake will be found in Sir A. Rumbold's despatch No. 83 of November 25, 1867, and in the diary of Mr. G. H. A. Porter, Administrator in the Virgin Islands, an extract from which is contained in despatch No. 96, December 23, 1867. This earthquake also created great damage in St. Thomas, St. John's, and St. Croix. It was accompanied by sea waves. Copies of these despatches were enclosed.

Trinidad.—Notes compiled by Mr. R. J. L. Guppy, M.A., late Inspector of Schools, refer to shocks on September 20, 1825, July 10, 1863, and January 10, 1888. All of these created considerable damage. Other shocks were noted on September 26, 1866, at 5.37 P.M.; July 7, 1868, 5.1 A.M.; November 17, 1885, 6.55 A.M.; May 7, 1886, 1.45 A.M.; May 17, 1886, 3.53 A.M.; May 5, 1887, 3.39 P.M.; January 10, 1888, 8.55 A.M.; October 5, 1890, 2.31 A.M.; November 20, 1890, 4.30 A.M. The time for these minor shocks is local.

Virgin Islands.—See St. Thomas, St. John's, and Tortola.

Cuba.—The British Minister and Consul-General, Mr. Stephen Leech, forwards a list of earthquakes, compiled by Mr. Consul Mason, recorded at Santiago de Cuba.

XII. *Seismic Activity* 1899-1903 *inclusive.*

The earthquakes referred to in the following list are those which have been recorded at stations all over the world, or at stations representing an area not less than that of Europe and Asia. Movements which have only been noted in a single continent have not been considered.

Although this catalogue may be used as a basis for many investigations, its main object is to show at a glance the regions in which important reliefs of strain have, in and beneath the crust of the world, taken place in recent years. The numbers given to the earthquakes

correspond to those of records obtained at Shide and published in British Association circulars. The small numbers which appear on the map (Plate II.) by their positions approximately indicate those of origins. The greater number of these, it will be observed, have been submarine. To make these determinations for each earthquake a list of the principal stations at which it had been recorded had to be drawn up. This showed the times at which P_1, P_2, P_3, and the maximum had been noted, together with the amplitudes recorded at each station. In the publications of the International Seismological Association, the Earthquake Investigation Committee of Japan, and in papers on particular earthquakes this fundamental data has for similar work always been published, but here it has been omitted. The reason for this is that it would occupy some three hundred pages, together with the fact that it can at any time be reproduced by consulting British Association and other Registers.

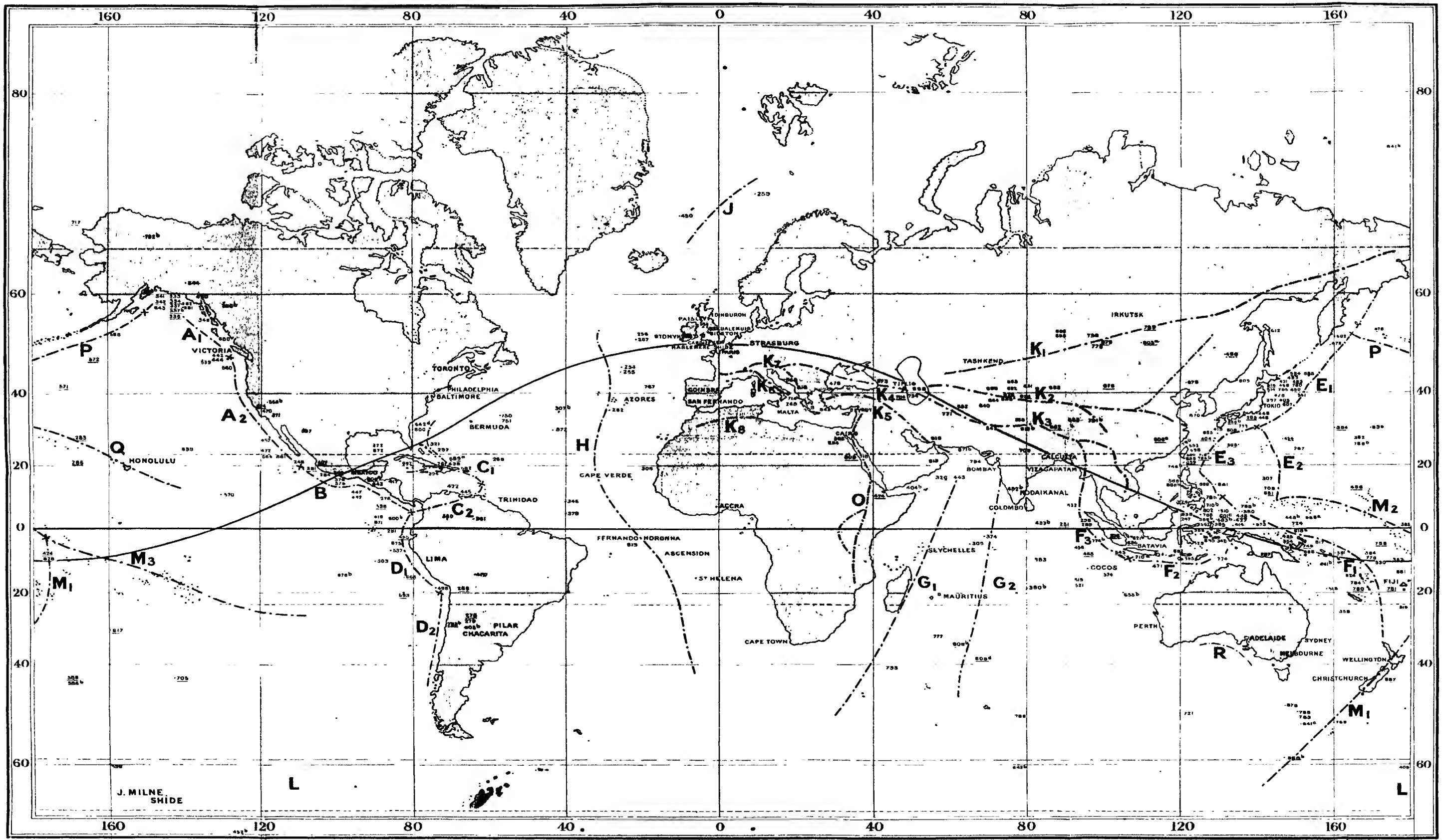
The names of places where an earthquake has been felt are followed by the letter 'F,' whilst those at which destruction has taken place are indicated by the letter 'D.' In these instances local observations in or near to an epifocal region have been used to determine the approximate position of a district from which an earthquake radiated and the time of its origin.

In cases where we have been without this local information, origins have been determined by selecting five or six stations at which the earthquake arrived first and where their amplitudes were large, and with this data we have computed the position sought, by methods well-known to seismologists. The method I find most satisfactory is that of circles (see British Association Report, 1900, p. 79). This has been applied to the differences in time at which P_1, P_2, P_3 or the maximum were recorded at *selected* stations. Another method which gives the distance of an origin from a station is the difference of time between the arrival of any two of these phases of motion. The results as to the times of occurrence at and position of an origin have been checked by comparing the computed times at which the earthquake should be noted at stations not included in the group of *selected* stations with the times actually recorded at the *non-selected* stations. In consequence of this method of working I have been led to the idea that certain seismograms which have hitherto been referred to as a single disturbance may refer to two or more disturbances (see p. 32). When an indicated time is followed by *plus* or *minus* two or more minutes, this also means that there is a corresponding uncertainty as to the position of an origin. All other times given may be read to within *plus* or *minus* one minute, unless they refer to records made in inhabited districts. These latter are probably correct to within 30 seconds.

The dotted lines on the map which are parallel to mountain ranges or oceanic ridges and troughs are the axes of districts from which many large earthquakes have originated. They are indicated by the letters A, B, C, &c. In the list two of these capital letters indicate that the earthquake originated near to the junction of two ridges.

The materials chiefly used for these investigations have been those obtained from stations co-operating with the British Association using

Origins of Large Earthquakes, 1899 1903.



Earthquake Districts are indicated A, B, C, &c. Small numbers refer to Shide Records (see British Association Circulars). If underlined were recorded all over the World.

Illustrating the Sixteenth Report on Seismological Investigations.

similar instruments. Most valuable assistance has however been received from the publications of the Earthquake Investigation Committee of Japan, the International Seismological Association, the Commission Sismique Permanente of the Imperial Academy of Sciences of St. Petersburg, the Société Sismologica Italiana, the K. Natuurkundige Vereeniging in Nederl-Indie, the Bulletins of the Manila Central Observatory, and the weekly, monthly, and other circulars issued by observers in various parts of the world.

The chief difference between the present map and the four corresponding maps already issued by the British Association is that it contains more entries and shows more clearly the present-day sites of seismic activity. The small numbers on the map which are underlined refer to earthquakes which have been recorded all over the world, whilst the remainder indicate earthquakes which were recorded over areas which are approximately those of half our sphere.

Dual or multiple earthquakes are linked by brackets, and the stations used for the determination of their origin are named.

Compilations referring to the next five years have been completed, but it was felt they could not be entered on the present map for want of space, and are therefore held over for the next Report.

The number of megaseisms which have taken place in the different regions in the period considered are as follows: A_1 twenty, A_2 eight, B fourteen, C_1 thirteen, C_2 five, D_1 six, D_2 seven, E_1 eighteen, E_2 seven, E_3 twenty-three, $E_{1,2,3}$ one, F_1 thirty-three, F_2 ten, F_3 twelve, G_1 five, G_2 seven, H fourteen, J two, K_1 ten, K_2 five, K_3 ten, K_4 four, K_5 three, K_6 three, K_7 two, K_8 nil, L four, M_1 twelve, M_2 eleven, M_3 two, O five, P five, Q five, R nil, B D_1 two, K_5G_1 four, F_1M_1 two, G_1G_2 one, P E_1 one, A_2B two, $K_{1,2,3}$ five, F_1E_3 three, $K_{2,3}$ one, F_1F_3 one, M_2E_2 three, K_1A_1 two. Total 313.

If we draw a circle 70° in radius, with its centre 180° east or west long. and 60° north lat., it will be seen that this passes through the most active seismic regions in the world. This circle is drawn on the map as a line. If it is replaced by a band 40° in width, it contains 186 entries out of the 313.

List of Earthquakes 1899-1903 *inclusive.*

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks F = felt. D destructive
		h. m.			
1899					
Jan. 12	247	8.0	F_2	128 E. 2 N.	Halmahera, F.
„ 14	248	2.37±2	A_2	110 W. 20 N.	
„ 22	249	8.14	K_5	21.30 E. 37 N.	Greece, Philiatri, Laconia, Kyparissia, D.
„ 24	250	23.45	B	99 W. 17 N.	Mexico Republic, Vera Cruz to St. Blas, Oaxaca, D.
„ 30	251	17.45	F_3	90 E. 0 N.S.	
„ 31	252	11.12	H	28 W. 35 N.	
Feb. 23	254	13.36±7	H	25 W. 45 N.	
„ 26	255	13.30±2	H	25 W. 45 N.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1899					
Feb. 27	256	11.17±2	H	20 W. 52 N.	
,, 27	257	15.21±3	H	22 W. 50 N.	
,, 28	259	19.33±3	J	10 E. 70 N.	
March 7	263	0.53	$E_{1, 2 \& 3}$	136 E. 33.8 N.	Japan, F.
,, 12	264	9.37±2	B	103 W. 17 N.	
,, 21	267	14.31±4	E_2	149 E. 24 N.	
,, 23	268*	10.23±5	D_2	67 W. 20 S.	
,, 23	269	14.26±2	C_1	59 W. 22 N.	
,, 25	270	14.27±3	B	87 W. 10 N.	
April 12	278	17.23	D_2	67 W. 28 S.	Rioja, Catamarca, Tucuman, D.
,, 13	279	3.36	D_2	67 W. 29.5 S.	
,, 16	282	14.38	A_1	138 W. 58 N.	
,, 17	283	1.36±3	M_1	167 W. 27 S.	
May 8	286	3.11±4	M_2	170 E. 20 N.	
June 5	291	4.30±2	B, D_1	85 W. 0 N.S.	
,, 5	292	15.2	C_1	73 W. 23 N.	
,, 14	294	11.6	C_1	77 W. 18 N.	Jamaica, Cinnamon Hill, F.
,, 17	295	1.8	E_1	145 E. 40 N.	
,, 24	298	16.57	F_3	97 E. 1 N.	Tapanooli, Sumatra, F.
,, 29	299	22.52	F_3	97 E. 1 N.	Tapanooli, Sumatra, F.
July 7	303	8.38±2	D_1	90 W. 10 S.	
,, 9	305	19.8±2	G_1	65 E. 5 S.	
,, 11	307	7.29±3	E_2	140 E. 15 N.	Dual Eqke.
,, 11	307*b*	7.36±3	H	42 W. 35 N.	
,, 12	308	1.35±2	H	20 W. 0 N.S.	
,, 14	308*b*	13.34±2	A_1	150 W. 60 N.	Dual Eqke.
,, 14	309	13.40	O	33 E. 23 N.	Distance A, to O. 98°
,, 17	310	10.0*ca*	F_1	130 E. 5 N.	Amboina F at 9.54 ?
Aug. 2	321	15.16	C_1	76 W. 23 N.	
,, 2	322	17.57	C_1	90 W. 25 N.	
,, 4	324	4.43	F_1	120 E. 8 N.	
,, 17	326	20.38	G_1, K_5	56 E. 16 N.	
,, 24	332	15.9±5	F_1, M_1	165 E. 27 S.	
Sept. 4	333	0.20	A_1	140 W. 59 N.	Yakutat Bay, D.
,, 4	334	4.53±2	A_1	140 W. 59 N.	,, ,,
,, 10	337	17.0	A_1	140 W. 59 N.	,, ,,
,, 10	337*b*	20.43	A_1	140 W. 59 N.	,, ,,
,, 10	338	21.38	A_1	140 W. 59 N.	,, ,,
,, 16	341	5.14	A_1	140 W. 59 N.	,, ,,
,, 17	342	12.51	A_1	140 W. 59 N.	,, ,,
,, 20	343	2.11±2	K_5	27.5 E. 37.5 N.	Aidin, Meander Valley Smyrna, D.
,, 23	344	11.4	A_1	140 W. 65 N.	
,, 23	345	13.43±2	A_1	133 W. 55 N.	
,, 27	346	8.1	H	40 W. 9 N.	
,, 29	347	17.1	F_3	129 E. 4 S.	Ceram Ambon, D.
Oct. 13	351	15.13±2	M_2	178 E. 15 S.	
,, 13	352	17.28±2	F_1	173 E. 10 S.	
,, 19	354	9.16±2	F_1	148 E. 5 S.	
,, 24	355	3.57	F_3	124 E. 9 S.	Kocheng Timor, F.
Nov. 12	358	23.43	F_1	162 E. 25 S.	
,, 18	361	14.55±3	C_2	65 W. 3 N.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1899					
Nov. 23	364	9.42±2	Q	160 E. 30 N.	
,, 24	365	9.56±3	F_1	128 E. 0 N.S.	
,, 24	366	18.39	F_1	136 E. 5 N.	Double Eqke.
,, 24	366*b*	18.41	E_2	131 E. 33 N.	Origin Kyushu, Japan
Dec. 25	371	12.25	A_2	117 W. 34 N.	San Jacinto, S. California, F.
,, 26	372	0.23	H	42 W. 30 N.	
,, 31	373	10.50	K_4	42 E. 42 N.	Akhalkalaki, D.
,, 31	374	20.19±2	$G_{1,2}$	68 E. 3 S.	
1900					
Jan. 5	376	18.56	F_3	102.5 E. 3 S.	Palembang, Sumatra, F.
,, 11	377	9.5±5	F_1	148 E. 5 S.	
,, 13	378	9.52±3	M_1	148 E. 48 S.	
,, 15	379	19.46±2	H	40 W. 5 N.	
,, 20	381	6.32	B	108 W. 19 N.	Mexico, Colima, Jalisco, Guerrero, D.
,, 29	383	22.30±3	G_2	82 E. 10 S.	
,, 31	385	18.50±3	M_2	178 E. 0 N.S.	
Feb. 3	386*b*	4.15±5	F_1	126 E. 2 N.	Akhalkalaki, D., also had shocks about this time.
,, 20	390*b*	21.36	G_2	80 E. 19 S.	
,, 26	391	3.41	A_1	140 W. 59 N.	
March 6	392	18.0	O	33 E. 28 N.	Cairo, F.
,, 9	394	2.18	M_2	168 E. 8 S.	
,, 12	397	1.32	E_1	142 E. 38 N.	N.E. Japan, Akita, Yamagata, F.
April 24	404	23.14	E_3	126.5 E. 27 N.	S.W. Japan, and Formosa and Oshima, F.
,, 30	404*b*	20.17	G_1	48 E. 12 N.	
May 11	405	17.21	E_1	144 E. 39 N.	N.E. Japan, Ishinomaki, F.
,, 16	407	20.13	B	105 W. 20 N.	Mexico, Colima, Jalisco, also Mexico City, D.
,, 26	408	15.59±3	L	0 E. & W. 60 S.	
June 9	411	12.11	E_3	130 E. 30 N.	Kiushiu.
,, 12	414	20.15±5	F_1	135 E. 0 N.S.	
,, 16	415	14.43±3	B	90 W. 3 N.	
,, 21	417	20.56±2	B	86 W. 15 N.	
July 15	422	18.49±2	C_2	70 W. 12 N.	
,, 29	424	6.59±3	M_2	178 W. 8 S.	
Aug. 5	425	4.18	E_1	144 E. 39 N.	Japan, Ishinomaki, F.
,, 13	427	20.13±2	F_1	137 E. 2 N.	
,, 28	430	10.59±3	J	10 W. 68 N.	
,, 29	431	2.32	E_1	145 E. 42 N.	
Sept. 1	432	7.56±1	D_1	94 W. 10 N.	Mexico, Ometepec, Coast of S. Luis Allende, F.
,, 9	433*b*	22.48	G_2	84 E. 0 N.S.	
,, 17	435	21.45±2	M_2	148 E. 5 S.	Herbertshöhe, Bismarck Archipel. F.
,, 20	438	18.57±3	F_1	136 E. 5 N.	
Oct. 7	441	21.0	F_1	130 E. 0 N.S.	
,, 8	441*b*	8.42±2	F_1	155 E. 12 S.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date		No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
			h. m.			
1900						
Oct.	9	442	12.27	A_1	132 W. 55 N.	Prince William Sound, Alaska, D.
,,	10	443	3.6 ±3	G_1	60 E. 16 N.	
,,	17	444	11.2	A_1	132 W. 55 N.	Prince William Sound, Alaska.
,,	29	445	9.26	C_2	68 W. 11 N.	Caracas, San Casimiro, Cua, D.
Nov.	5	446	7.30	E_2	139 E. 34 N.	Omori gives 139.5 E. 33.43 N. Izu, F.
,,	9	447	16.7±2	B	96 W. 11 N.	Dual Eqke.
,,	9	448	17.52	E_2	139 E. 34 N.	Nagatsuro, Izu., F.
,,	12	448*b*	1.6	F_1	147 E. 3 N.	
,,	24	450	7.54	E_1	148 E. 40 N.	Nemuro, F.
Dec.	18	452*b*	22.4±2	L	125 W. 67 S.	Dual Eqke.
,,	18	452	23.15±2	A_2	120 W. 27 N.	
,,	25	454	5.2±3	E_2	146 E. 27 N.	This may be dual.
1901						
Jan.	7	455	0.30±5	D_1	82 W. 2 S.	
,,	8	456	19.38±2	F_3	92 E. 6 S.	Malabar, Java, F.
,,	13	458	22.36±3	E_1	145 E. 42 N.	Awomori, Japan, F.
,,	18	460	4.41*ca*	A_1	135 W. 60 N.	
Feb.	15	468	8.12±1	F_2	95 E. 8 S.	
,,	20	468*a*	9.36±4	F_1	152 E. 3 N.	
March	3	470	7.45±1	A_2	120 W. 35.30 N.	
,,	4	471	16.12±3	F_2	113 E. 12 S.	Bima, Soembawa, F.
,,	5	472	10.45±2	A_2	120 W. 23 N.	But Robbles, California, is 35° N., F.
,,	16	474	11.56±2	O	40 E. 10 S.	
,,	18	475	23.24*ca*	E_1	159 E. 50 N.	Two shocks.
,,	19		23.46±2	E_1	159 E. 50 N.	Nemuro, F. at 23.50.
,,	23	476	14.10±3	P	170 E. 55 N.	
,,	31	479	7.11	K_7	28.30 E. 44 N.	
April	5	483*b*	21.53±2	F_1	130 E. 2 N.	Todano, Celebes, F.
,,	5	483	23.32	E_1	149 E. 44 N.	Japan, Nemuro, F.
,,	6	486	20.55±3	K_1	132 E. 55 N.	
,,	27	492*b*	4.5	G_2	75 E. 12 N.?	
May	14	493	6.49	E_1	148 E. 42 N.	Nemuro, F.
,,	25	496	0.32±2	M_2	165 E. 12 N.	
,,	26	497	7.40	D_1, D_2	63 W. 15 S.	
,,	27	498	16.25±3	C_1	70 W. 20 N.	
June	7	500	0.3	E_3	121 E. 23 N.	Formosa, Giran, D.
,,	13	502	3.19±2	P, E_1	160 E. 52 N.	
,,	24	505	7.3	E_2	135 E. 25 N.	Omori gives 130 E. 28 N., 7.6 G.M.T. at Tokio. Loo Choo, Oshima, F.
Aug.	6	513	18.39±3	G_1, K_5	55 E. 20 N.	
,,	9	514	9.21	E_1	144 E. 40 N.	Japan, Miyako, Kushiro, F.
,,	9	515	13.1±1	F_1	159 E. 20 S.	
,,	9	516	18.32	E_1	144 E. 40 N.	Japan, Miyako, Hakodate, F.
,,	10	517	10.27±3	F_1	155 E. 5 S.	
,,	11	518	14.32±2	M_2	178 E. 23 S.	
,,	18	519	2.5±4	S of F_3	92 E. 17 S.	
Sept.	7	529	22.34±2	F_2	125 E. 5 S.	Celebes, Tontoli, F.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long in degrees	Remarks. F = felt, D = destructive
		h. m.			
1901					
Sept. 8	530	17.42±2	F_1	170 E. 11 S.	
,, 10	532	4.26±1	F_3	90 E. 7 N.	
,, 30	534	10.6±2	Q	170 E. 30 N.	
Oct. 8	536	2.16±2	B	90 W. 7 N.	
,, 11	537	2.56±3	D_1	85 W. 7 S.	
,, 15	539	13.23±2	A_1	134 W. 53 N.	
,, 17	542	5.57±2	K_3	70 E. 30 N.	
,, 19	543	9.0*ca*	F_3		Origin near Java, many shocks.
,, 29	548	8.42	K_6	19 E. 44 N.	Raca, Servia, F.
Nov. 8	551	6.3	E_1	150 E. 40 N.	
,, 13	555	10.16	F_1	122 E. 0 N.S.	
,, 14	555*b*	4.35±1	A_2	117 W. 37 N.	Oasis, Beaver, Salt Lake City, U.S.A., F.
,, 15	557	20.15	M_1	173 E. 43 S.	Cheviot, New Zealand, D.
,, 18	558	0.4	K_3	77 E. 32 N.	
,, 20	560	23.57	A_1	130 W. 50 N.	
,, 25	562	1.51	F_1	127 E. 3 N.	Ternate, F.
Dec. 9	564	2.17±2	A_2	120 W. 23 N.	
,, 14	565	22.54	E_3	121 E. 14 N.	Batangas, Philippines, D.
,, 26	568*b*	9.58±2	M_1	140 E. 58 S.	
,, 30	569	22.34	P	160 W. 52 N.	Kenai, Alaska, D.
,, 31	570	5.51	Q	130 W. 10 N.	
,, 31	571	9.0±2	P	173 W. 41 N.	
1902.					
Jan. 1	572	6.20±2	P	165 W. 47 N.	
,, 12	574	22.24	F_3	100 E. 15 S.	About 22^h.0 Eqke. at Donggala, Tontoli and Sakitta.
,, 16	576	23.53	B	99 W. 17 N.	Chilpancingo, D.
,, 18	578	23.23±2	B	94 W. 16 N.	
,, 21	580	21.40±2	C_2	71 W. 3 N.	
,, 24	581	23.23±3	F_1	161 E. 8 S.	
,, 28	582	18.48±2	C_1	68 W. 20 N.	
,, 30	584	13.59	E_1	145 E. 43 N.	Japan, Tokachi, F.
,, 31	585	1.41	E_1	145 E. 43 N.	,, ,,
Feb. 9	586	7.43±3	M_1	171 W. 43 S.	
,, 9	586*b*	10.12±3	M_1	171 W. 43 S.	
,, 13	588	9.34.6 or 9.39	K_4	50 E. 41 N.	Shemaka, D.
,, 17	589*a*	0.39±2	C_1	70 W. 20 N.	
,, 25	590	15.35±2	F_1	127 E. 0 N.S.	
March 1	592	0.13	E_2	122 E. 24 N.	Formosa, Taihoku, F.
,, 5	593	19.3±3	D_2	83 W. 20 S.	
,, 12	596	15.7	L	160 W. 60 S.	
,, 17	597	11.22	A_2, B	109 W. 30 N.	
,, 20	598	1.50?	E_2	122 E. 24 N.	
,, 22	599	22.12±2	Q	140 W. 23 N.	
,, 24	600	17.58±2	C_1	80 W. 31 N.	
,, 25	600*b*	3.26±3	B, D_1	87 W. 3 N.	
,, 28	601*c*	14.43	F_1	130 E. 3 N.	Halmahera, Banda, F.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1902					
April 11	605*a*	23.41	K_1	110 E. 50 N.	Double quake. Distance between origins 155°.
„ 11	605*b*	23.55	D_2	65 W. 27 S.	
„ 19	606*a*	2.22	B	91.30 W. 15 N.	Amatitlan, Guatemala, D.
„ 19	606*b*	2.34±3	G_2	60 E. 35 S.	Origin determined from Wellington, Perth, Capetown, Bombay, Kodaikanal, Calcutta, and Batavia.
„ 19	606*c*	2.36	W. of F_2.	113 E. 27 N.	Origin determined from Tokio, Manila, and Irkutsk.
„ 21	606*d*	17.26	G_2	68 E. 40 S.	
May 2	607	11.29	E_1	144 E. 39 N.	Awomori, Japan, F.
„ 8	609	2.19	E_3	132 E. 30 N.	S. E. coast of Kiushiu, F.
„ 25	610	17.20*ca*	K_2		Western Asia.
June 11	612	6.10	K_1	142 E. 53 N.	
„ 16	613*b*	1.36	K_2	79 E. 29 N.	
July 5	616	14.59	K_7	23 E. 40 N.	Bani, Salonica, D.
„ 6	617	13.1	M_2	160 W. 31 S.	
„ 9	618	3.38	K_5	56 E. 27 N.	Bander Abbas, Kishim Id., D.
„ 20	619	8.49	H	25 W. 5 S.	
Aug. 2	619*b*	14.13±2	M_2	150 E. 0 N.S.	
„ 7	621*b*	11.46	F_2	108 E. 4 S.	Palembang, Batavia, F.
„ 16	624	8.0±3	F_1	165 E. 15 S.	
„ 21	625	11.17	E_3	124 E. 8 N.	Centre of Mindanao, D.
„ 22	626	3.1	K_1, K_2, K_3	75 E. 40 N.	Kashgar, Artush, D.
„ 23	631	12.58±2	K_1, K_2, K_3	79 E. 41 N.	
„ 24	632	1.45	K_1, K_2, K_3	75 E. 40 N.	
„ 29	635	15.4	K_1, K_2, K_3	75 E. 40 N.	
„ 30	636	21.47	K_1, K_2, K_3	76 E. 40 N.	
Sept. 16	639	10.54	E_3, F_1	122 E. 6 N.	Solo and Basilan, F.
„ 20	640	6.30	K_2	70 E. 37 N.	Srinagar, F.
„ 22	641	1.44	E_2	130 E. 13 N.	Guam, D.
„ 22	641*b*	1.46	K_1	175 E. 75 N.	Determined by Irkutsk, Victoria, Toronto, and European stations.
„ 22	641*c*	1.56	M_1	152 E. 52 S.	Determined by 'Discovery,' Christchurch, Wellington, and Perth.
„ 23	642	20.16	B	90 W. 15 N.	Mexico, Tuxtla, F.
„ 23	642*b*	20.29*ca*	G_2	77 E. 60 S.	Origin determined from Perth, Batavia, Mauritius, and Capetown.
„ 24	642*d*	4.54	C_1	80 W. 31 N.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1902					
Oct. 2	643	17.48	A_1	145 W. 58 N.	
,, 6	644	9.10	K_3	72 E. 38 N.	Ferghana, D.
Nov. 4	653	11.35	K_2, K_3	91 E. 32 N.	
,, 15	655	9.30	E_3	128 E. 28 N.	Origin determined from Tokio, Manila, and Irkutsk.
,, 15	655*b*	9.33	F_2	105 E. 20 S.	Origin determined from Bavaria, Kodaikanal, 'Perth, Capetown, Discovery.'
,, 17	656	0.36	E_3	121 E. 14 N.	Batangas, D.
,, 20	658	20.32	E_3	121 E. 21 N.	North of Philippines. Another eqke. near Christchurch at same time, determined from Christchurch, Perth, and Batavia.
,, 21	659	7.3	E_3	120 E. 21 N.	Batanes Is. and Taito, F.
Dec. 12	661	23.5±2	A_2, B	118 W. 23 N.	
,, 13	662	17.8±2	K_3	85 E. 30 N.	
,, 16	663	5.8	K_2	75 E. 42 N.	Andijan, D.
,, 28	666	1.41	K_1	88 E. 52 N.	Bijsk, Altai Mts., D.
1903.					
Jan. 4	668	4.55±5	D_2	83 W. 15 S.	Origin determined from Christchurch, Toronto, Victoria, B.C., England, Capetown, and Mauritius.
,, 4	668*b*	5.17	E_3	120 E. 13 N.	Origin determined from Manila, Irkutsk, Perth, and Bombay.
,, 5	670	21.59	E_3	124 E. 34 N.	Chinnampo, S.W. Korea, F.
,, 14	671	1.44	B	90 W. 3 N.	Suggested by Indian, Siberian stations and Batavia.
,, 14	671*b*	2.46	K_5, G	64 E. 24 N.	
,, 17	672	16.12	C_1	88 W. 25 N.	
,, 19	673	12.36	F_1	140 E. 1 N.	
,, 24	674	5.25±3	A_3	120 W. 27 N.	
,, 24	675	15.37±2	D_1	86 W. 5 S.	
Feb. 1	676	9.33	K_3	102 E. 42 N.	
,, 2	676*b*	9.30*ca*	D_1'	100 W. 15 S.	
,, 5	678	18.26*ca*	M_3	178 W. 8 N.	Origin determined from Victoria, Irkutsk, Batavia, Calcutta, Kodaikanal, Bombay, and England.
,, 6	679	7.33	K_1	98 E. 50 N.	
,, 10	681	2.48±2	E_3	142 E. 11 N.	Agana, Guam, D.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1903					
Feb. 11	682	16.5	F_2	110 E. 8 S.	Bima, Soembawa, F.
„ 12	683	18.42	K_2	87 E. 40 N.	
„ 24	685	17.33	F_1	152 E. 8 S.	
„ 27	686	0.44	F_2	104 E. 5 S.	Tais, Sumatra, F.
„ 28	687	9.50	C_1	81 W. 20 N.	Origin determined from Trinidad, Toronto, Victoria, British stations and Bombay. Wellington does not agree, perhaps another quake.
March 12	689	14.19	K_1	87 E. 54 N.	Kuznesk, D.
„ 15	690	14.13	A_1	128 W. 51 N.	
„ 22	692	14.35	K_3	60 E. 35 N.	
„ 25	694	22.27	O	27 E. 27 N.	Origin determined from Tiflis, Tashkent, Shide and Capetown.
„ 28	696	7.55	K_2	72 E. 40 N.	Ferghana, Marghilan, Kojend, D.
„ 29	698	16.28*ca*	D_2?		Argentina, F.
„ 30	699	3.23	F_2	126 E. 3 S.	Boeroe, Masarete, F.
April 3	700	10.32	P	157 W. 57 N.	
„ 12	703	3.13±3	Uncertain		
„ 28	704	23.40	K_4	43 E. 39 N.	Melazghird, L. Van, D.
„ 29	705	3.59±4	M_2.	143 W. 43 S.	
May 13	707	6.32	M_2, E_2	142 E. 8 N.	
„ 15	708	11.41*ca*	M_2, E_2	142 E. 12 N.	Determined from Manila, Tokio, Irkutsk, Calcutta and Perth. Honolulu and Victoria do not agree.
„ 17	709	1.0	K_3	80 E. 23 N.	This origin does not agree with records for Perth, W.A.
„ 23	710*a*	20.7	F_2	110 E. 8 S.	Determined from Batavia, Perth and Mauritius.
„ 23	710*b*	22.7	E_2	126 E. 7 N.	Davao, Mindanao, F. Determined from 'Discovery,' Manila, Tokio, Irkutsk and European stations.
„ 29	714	9.33	K_4	20 E. 39 N.	Corfu, F.
June 2	717	13.10±2	K_1, A_1	170 W. 67 N.	
„ 4	718	15.12±5	O	37 E. 23 N.	
„ 7	719	9.5	E_2	122 E. 21 N.	Batanes Ids., F.
„ 8	721	5.23±3	M_1	121 E. 50 S.	
„ 10	724	16.31	F_1	149 E. 0 N.S.	
„ 24	734	16.56	K_4	49 E. 39 N.	Lenkoran, F.
„ 25	736	22.12	K_1	06 E. 51 N.	
July 2	738	21.22	M_1	150 E. 50 S.	
„ 12	746	5.27?	F_1	150 E. 5 S.	
„ 23	748*b*	22.36	E_2	121 E. 19 N.	Luzon, Aparri, F.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date		No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
			h. m.			
1903						
July	27	750	10.34	H	57 W. 33 N.	
,,	27	751	12.32*ca*	H	57 W. 33 N.	
Aug.	11	759	4.30	K_6	23 E. 36½ N.	Greece, Potamos, Mytata, D.
,,	13	760	15.46	E_1	146 E. 41 N.	
,,	16	761	13.35±5	C_1	72 W. 20 N.	Jamaica, Unity, F.
Sept.	7 ●	764*a*	7.10	M_1	175 E. 71 S.	Determined from Christchurch, Perth, and Honolulu.
,,	7	764*b* ●	7.14	E_3	122 E. 23 N.	Determined from Irkutsk, Krasnoyarsk, Bombay, Capetown, and British stations.
,,	8	765	5.7	L	78 E. 50 S.	
,,	10	766*b*	13.48	A_1	130 W. 58 N.	
,,	13	767	15.31*ca*	H	19 W. 41 N.	
,,	23	769	0.14	M_1	160 E. 52 S.	
,,	25	771	1.20±3	K_3	58 E. 34 N.	Persia, Turschis, D.
Oct.	10	773	16.41	E_2	132 E. 32 N.	Japan, Hyuga, F.
,,	14	774	3.20*ca*	F_2	128 E. 11 S.	Timor, Atapocpoe, F. Determined from Manila, Perth, Batavia.
,,	19	774*b*	3.5*ca*	F_3	98 E. 3 S.	Lais, Sumatra, F.
,,	20	775	2.47	F_1	168 E. 9 S.	
,,	21	777	9.50*ca*	G_1	55 E. 33 S.	
,,	23	778	2.36	K_1	97 E. 50 N.	
,,	29	780	14.19	F_1	167 E. 20 S.	
,,	30	781	3.54	F_1	175 E. 20 S.	
Nov.	10	783	17.17	M_1	150 E. 50 S.	
,,	10	784	20.46	F_1	167 E. 17 S.	
,,	17	785	20.23±2	E_8	126 E. 9 N.	Philippines, Surigao, F.
,,	24	788	13.34	F_1, E_8	125 E. 3 N.	Celebes, Bolaang, F.
,,	26	789	11.46	K_1	110 E. 53 N.	Send, L. Baikal, D.
Dec.	1	789*b*	6.43	Q	165 E. 25 N.	
,,	1	790	14.21	E_3	120 E. 24 N.	
,,	3	791*b*	●21.26	K_3	93 E. 32 N.	
,,	5	792*b*	5.7	K_1, A_1	150 W. 66 N.	
,,	6	793	22.48	G_1	45 E. 41 S.	Felt at Cairo, 23.34.
,,	7	793*b*	14.40±3	D_2	71 W. 28 S.	Chili, Vallenar, D.
,,	10	794	7.8	K_5, G_1	65 E. 21 N.	
,,	18	796*b*	12.18	E_2, M_2	135 E. 5 N.	
,,	23	798	0.53	M_2	170 E. 5 S.	Determined from Christchurch, Honolulu, Batavia, and Irkutsk. 40m. later another eqke. recorded at British and Azores stations.
,,	28	802	2.50±2	F_1, E_8	123 E. 3 N.	Celebes, Tontoli, F.

XIII. *Sensibility of Seismographs recording on Smoked Surfaces.*

On several occasions in the British Association Reports I have given illustrations of the marked want of sensitiveness of seismographs which record on smoked surfaces.[1] Instruments which work in this manner are inexpensive to maintain, you can at any time see your record, and they yield most excellent seismograms of strong disturbances. However, in consequence of the elasticity of the writing levers, and possibly for other reasons, they do not commence to give a record until a certain amplitude of motion has been reached. They therefore fail to record minute movements, and as these may frequently represent that which remains of an earthquake originating at a great distance, those who use these types of instrument are entirely cut off from what I have called a 'New Departure in Seismology.' As bearing upon this point I give the following quotations from the report of the Director, Bombay and Alibag Observatories, 1910. The italics are mine:—

Milne's Seismograms, *photographic Records.*	There was no loss of record.	The action of the instrument is voluntarily interrupted, *e.g.*, for regular changing of the film, winding and rating the watch and clock, adjustment and examination of the instrument, deflection experiments, &c; such interruptions are not taken into consideration.
Vertical movement Seismograms.	Out of 9 principal disturbances 7 were recorded and 1 was not recorded.	1 disturbance was partially lost in shifting time.
	Out of 48 small disturbances 20 were recorded and 26 were not recorded.	2 disturbances were lost as the paper did not come out.
Colaba No. 1 (E. W.) Seismograms.	Out of 9 principal disturbances 8 were recorded.	1 disturbance was partially lost in shifting time.
	Out of 48 small disturbances 37 were recorded and 8 were not recorded	2 disturbances were lost in shifting time and 1 was lost owing to the *smoked paper* being destroyed.
Colaba No. 2 (N.-S.) Seismograms.	Out of 9 principal disturbances 8 were recorded.	1 disturbance was partially lost in shifting time.
	Out of 48 small disturbances 31 were recorded and 13 were not recorded.	1 was lost owing to the stoppage of clock; 2 were lost in shifting time, and 1 was lost owing to the *smoked paper* being destroyed.
Omori Seismograms.	Out of 9 principal disturbances all were recorded.	
	Out of 48 small disturbances 36 were recorded and 11 were not recorded.	1 was lost owing to the *smoked paper* being destroyed.

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[1] See *Brit. Assoc. Seis. Reports*, 1909, p. 51, 'Aftershocks of the Earthquake at Jamaica'; 1910, p. 48, 'A New Departure in Seismology.'

Milne's seismograph registered *fifty-seven* earthquakes during the year under report, besides several small local and other movements. Of these, three were great disturbances—namely, those recorded on November 9 and 13 and December 16.

The seismograph for recording vertical movements registered *twenty-seven* disturbances.

The Japanese (Omori) seismograph recorded *forty-five* disturbances.

The Colaba seismographs No. 1 (E.-W.) and No. 2 (N.-S) recorded *forty-five* and *thirty-nine* disturbances respectively.

The Further Tabulation of Bessel and other Functions.—Report of the Committee, consisting of Professor M. J. M. HILL (*Chairman*), Dr. J. W. NICHOLSON (*Secretary*), Professor ALFRED LODGE, Dr. L. N. G. FILON, *and* Sir GEORGE GREENHILL.

PART I.—*Elliptic Functions.*

DURING the course of the year Sir George Greenhill has brought forward a scheme for the rearrangement of the Elliptic Function Tables on a new basis.

This scheme would, in the event of its acceptance by the Association, occupy the greater part of the attention of the Committee for some time, and would also involve a grant from the Association towards the expense of computing.

It seems desirable, therefore, that the report for the present year should be concerned mainly with this question; and a brief outline, with some specimen tables indicating the nature of the proposed work, is accordingly submitted to the Association for its approval or criticism.

Subjoined is a specimen table for modular angle $\theta = 45°$ and $\theta = 75°$, which may be taken as typical of the proposed work. The notation used is such that, for example, $\Theta(0)$ is denoted by $\Theta 0$, and $\mathrm{H}(K)$ by $\mathrm{H}K$.

The argument of the table proceeds by degrees of the quadrant of the quarter period K or F (90°), instead of degrees of $\phi = \operatorname{am} fK$, as in Legendre's Table IX.

The four columns of A, B, C, D give at $r°$, where $r = 90f$,

$$D(r°) = \frac{\Theta fK}{\Theta 0}, \qquad A(r°) = \frac{\mathrm{H}fK}{\mathrm{H}K},$$

$$B(r°) = A(90 - r) = \frac{\mathrm{H}(1-f)K}{\mathrm{H}K},$$

$$C(r°) = D(90 - r) = \frac{\Theta(1-f)K}{\Theta 0}$$

so that the table proceeds from 0° to 45°, and then turns back again upward, as in the ordinary trigonometrical table of a circular function.

The elliptic functions are given then by

$$\sqrt{\kappa'}\,\operatorname{sn} fK = \frac{A}{D}, \qquad \operatorname{cn} fK = \frac{B}{D}, \qquad \frac{\operatorname{dn} fK}{\sqrt{\kappa'}} = \frac{C}{D},$$

instead of the usual form of Jacobi

$$\sqrt{\kappa}\,\operatorname{sn} fK = \frac{\mathrm{H}fK}{\Theta fK}, \qquad \sqrt{\frac{\kappa}{\kappa'}}\,\operatorname{cn} fK = \frac{\mathrm{H}(1-f)K}{\Theta fK}.$$

Elliptic Function Table. $\theta = 45°$.

$\kappa = \sin 45° = \kappa'$, K = 1·85407 = K', E = 1·35064 = E'; $q = e^{-\pi} = 0·043214$, $\frac{1}{q} = e^{\pi} = \text{al } 1·36438 = 23·141$.

r (= 90f)	fK = Fϕ	ϕ = am fK (in degrees)	E zn fK = E$\phi - f$E	D $= \frac{\Theta f \text{K}}{\Theta 0}$	A $= \frac{\text{H} f \text{K}}{\text{HK}}$	B $= \frac{\text{H}(1-f)\text{K}}{\text{HK}}$	C $= \frac{\Theta(1-f)\text{K}}{\Theta 0}$	F zn $(1-f)$K = E$\phi - (1-f)$E	ϕ = am $(1-f)$K (in degrees)	$(1-f)$K = Fϕ	r = 90$(1-f)$
Degrees.											
0	0·0000	00·00	0·0000	1·0000	0·0000	1·0000	1·1892 (1·1892071)	0·0000	90 00	1·8541 (1·85407)	90
1	0·0206	1·18									89
2											88
3	0·0618	3·57	0·0167	1 0005	0 0520	0 9949	1·1887	0·0140	87·49	1·7923	87
4											86
5											85
6	0·1236	7·07	0·0331	1·0021	0·1038	0·9909	1·1871	0 0280	84·99	1·7305	84
7											83
8											82
9	0·1854	10·59	0·0491	1·0046	0·1553	0·9842	1·1846	0·0416	82·47	1·6687	81
10											80
11											79
12	0·2472	14·09	0·0644	1·0082	0·2064	0·9748	1·1811	0 0550	79·93	1·6069	78
13											77
14											76
15	0·3090	17·56	0·0789	1·0127	0·2570	0·9628	1·1765	0·0679	77·40	1·5451	75
16											74
17											73
18	0·3708	21·01	0·0923	1·0181	0·3069	0·9482	1·1711	0·0802	74·81	1·4833	72
19											71
20											70

$r = 90(1-f)$	$(1-f)K = F\phi$	$\phi = \mathrm{am}(1-f)K$	$\mathrm{zn}(1-f)K$ F	$\frac{\Theta(1-f)K}{\Theta 0}$ C	$\frac{H(1-f)K}{HK}$ B	$\frac{HfK}{HK}$ A	$\frac{\Theta fK}{\Theta 0}$ D	$\mathrm{zn}\,fK$ E	$\phi = \mathrm{am}\,fK$	$fK = F\phi$	$r = 90f$
21 22 23	0·4326	24·42	0·1045	1·0243	0·3561	0·9310	1·1649	0·0919	72·20	1·4215	69 68 67
24 25 26	0·4944	27·78	0·1153	1·0318	0·4042	0·9113	1·1579	0·1027	69·57	1·3597	66 65 64
27 28 29	0·5562	31·10	0·1248	1·0390	0·4518	0·8891	1·1502	0·1127	69·90	1·2979	63 62 61
30	0·6180 (0·618023)	34·37 (34·37274)	0·1325 (0·13253)	1·0473 (1·047463)	0·4972 (0·4972411)	0·8644 (0·8646158)	1·1419 (1·141685)	0·1216 (0·1216)	64·19 (64·18787)	1·2361 (1·2360467)	60
31 32											59 58
33 34 35	0·6798	37·59	0·1387	1·0561	0·5418	0·8368	1·1331	0·1293	61·44	1·1743	57 56 55
36 37 38	0·7416	40·76	0·1433	1·0654	0·5849	0·8069	1·1238	0·1358	58·63	1·1124	54 53 52
39 40 41	0·8034	43·88	0·1461	1·0749	0·6265	0·7749	1·1143	0·1410	55·79	1·0507	51 50 49
42 43 44	0·8653	46·94	0·1473	1·0847	0·6664	0·7406	1·1045	0·1446	52·89	0·9889	48 47 46
45	0·9271 (0·927035)	49·94 (49·939667)	0·1467 (0·1464466)	1·0946 (1·094586)	0·7045 (0·7044708)	0·7045 (0·7044708)	1·0946 (1·094586)	0·1467 (0·1464466)	49·94 (49·939667)	0·9271 (0·927035)	45

Elliptic Function Table: . $\theta = 75°$.

$K = 2{\cdot}76806$, $K' = 1{\cdot}59814$, $E' = 1{\cdot}54415$, $E = 1{\cdot}07640$, $q = \exp\frac{-\pi}{\sqrt{3}}$, $\frac{1}{q} = \exp\frac{\pi}{\sqrt{3}}$.

r $(= 90f)$	$fK = F\phi$	$\phi = \mathrm{am}\,FK$ (in degrees)	E $\mathrm{zn}\,fK = E\phi - fE$	D $= \frac{\Theta fK}{\Theta 0}$	A $= \frac{HfK}{HK}$	B $= \frac{H(1-f)K}{HK}$	C $= \frac{\Theta(1-f)K}{\Theta 0}$	F $\mathrm{zn}(1-f)K = E\phi - (1-f)E$	$\phi =$ $\mathrm{am}\,(1-f)K$ (in degrees)	$(1-f)K = F\phi$	$r = 90(1-f)$
0	0·0000	0·00	0·0000	1·0000	0·0000	1·0000	1·9677 (1·9656306)	0·0000	90·00	2·7681 (2·76806)	90
1 2 3	0·0923	5·28	0·0523	1·0027	0·0469	0·9983	1·9650	0·0272	88·63	2·6759	89 88 87
4 5 6	0·1845	10·52	0·1036	1·0106	0·0938	0·9934	1·9571	0·0545	87·25	2·5836	86 85 84
7 8 9	0·2768	15·67	0·1530	1·0237	0·1406	0·9852	1·9440	0·0820	85·86	2·4913	83 82 81
10 11 12	0·3691	20·71	0·1995	1·0418	0·1873	0·9738	1·9258	0·1098	84·41	2·3990	80 79 78
13 14 15	0·4614	25·60	0·2424	1·0648	0·2338	0·9598	1·9028	0·1378	82·93	2·3068	77 76 75
16 17 18	0·5536	30·31	0·2809	1·0924	0·2801	0·9417	1·8753	0·1660	81·39	2·2145	74 73 72
19 20 21	0·6459	34·83	0·3144	1·1243	0·3260	0·9212	1·8434	0·1944	79·79	2·1222	71 70 69

$r = 90(1-f)$	$(1-f)K = F\phi$	$\phi = \mathrm{am}\,(1-f)$	$\mathrm{zn}\,(1-f)K$ F	$\frac{\Theta(1-f)K}{\Theta 0}$ C	$\frac{H(1-f)K}{HK}$ B	$\frac{H fK}{HK}$ A	$\frac{\Theta fK}{\Theta 0}$ D	$\mathrm{zn}\,fK$ E	$\phi = \mathrm{am}\,fK$	$fK = F\phi$	$r = 90f$
22											68
23											67
24	0·7352	39·13	0·3426	1·1601	0·3716	0·8979	1·6075	0·2225	78·11	2·0800	66
25											65
26											64
27	0·8304	43·21	0·3650	1·1994	0·4167	0·8720	1·7682	0·2501	76·33	1·9377	63
28											62
29											61
30	0·9227	47·06	0·3815	1·2419	0·4612	0·8406	1·7257	0·2770	74·45	1·8454	60
	(0·922687)	(47·058121)	(0·3799178)	(1·2382723)	(0·4611631)	(0·8435712)	(1·721084)	(0·2781193)	(74·453790)	(1·845378)	
31											59
32											58
33	1·0150	50·68	0·3922	1·2870	0·5050	0·8210	1·6806	0·3024	72·46	1·7531	57
34											56
35											55
36	1·1073	54·09	0·3971	1·3343	0·5480	0·7961	1·6333	0·3261	70·33	1·6609	54
37											53
38											52
39	1·1995	57·27	0·3964	1·3822	0·5900	0·7658	1·5844	0·3473	68·06	1·5686	51
40											50
41											49
42	1·2915	60·25	0·3906	1·4332	0·6309	0·7391	1·5344	0·3655	65·63	1·4763	48
43											47
44											46
45	1·3841	63·04	0·3802	1·4838	0·6705	0·6705	1·4838	0·3802	63·04	1·3841	45
	(1·38403)	(63·133802)	(0·3705905)	(1·478625)	(0·6704649)	(0·6704649)	(1·478625)	(0·3705905)	(63·133802)	(1·38403)	

The column of E and F gives

$$E(r^\circ) = \text{zn}\, f\text{K} = E\phi - f\text{E},$$

$$F(r^\circ) = E(90 - r) = \text{zn}\,(1 - f)\,\text{K}$$

and

$$\phi = \text{am}\, f\text{K}, \qquad f\text{K} = F\phi.$$

If the small Theta function is preferred, K must be replaced by $\frac{1}{2}\pi$, and $\Theta f\text{K}$ by $\theta(\frac{1}{2}\pi f)$, $\text{H}f\text{K}$ by $\theta_1(\frac{1}{2}\pi f)$, but the numerical entry in the Table is unaltered.

The value of A, B, C, D is chosen as the quotient of two Theta functions, because it can be expressed algebraically, and calculated to any desired number of decimal places, for a Division value of the Elliptic Function; and so the accuracy may be tested of the terms of a series employed in the computation.

Thus at the Bisection, $f = \frac{1}{2}$, $r = 45$, and

$$E(45) = F(45) = \text{zn}\,\tfrac{1}{2}\text{K} = \tfrac{1}{2}(1 - \kappa')$$

$$\kappa = \sin\theta,\ \kappa' = \cos\theta$$

$$D(45) = C(45) = \left(\frac{1+\kappa'}{2\kappa'^{\frac{3}{2}}},\right)^{\frac{1}{4}},$$

$$A(45) = B(45) = \left(\frac{\kappa'^{\frac{1}{2}}}{2(1+\kappa')}\right)^{\frac{1}{4}}$$

$$\text{sn}\,\tfrac{1}{2}\text{K} = \sqrt{\left(\frac{1}{1+\kappa'}\right)}, \quad \text{cn}\,\tfrac{1}{2}\text{K} = \sqrt{\left(\frac{\kappa'}{1+\kappa'}\right)}, \quad \text{dn}\,\tfrac{1}{2}\text{K} = \sqrt{\kappa'}.$$

At Trisection, in the region $3 > b > 1$,

$$\kappa^2 = \frac{(b+1)^3\,(3-b)}{16b}, \quad \kappa'^2 = \frac{(b-1)^3\,(b+3)}{16b}$$

$$D(30) = C(60) = \frac{(b^2-1)^{\frac{1}{4}}}{2\sqrt{\kappa'}}$$

$$D(60) = C(30) = \frac{(b+1)^{\frac{1}{2}}}{(b-1)^{\frac{1}{2}}}$$

$$A(30) = B(60) = \frac{(b-1)^{\frac{1}{4}}}{(b+1)^{\frac{1}{4}}}$$

$$A(60) = B(30) = 2\sqrt{\kappa'}.\,\frac{b^{\frac{1}{2}}}{(b^2-1)^{\frac{1}{4}}}$$

$$E(30) = F(60) = \frac{9-b^2}{12b^{\frac{1}{2}}}$$

$$E(60) = F(30) = \frac{(3-b)b^{\frac{1}{2}}}{6}$$

The value

$$b = 3^{\frac{1}{4}}\,\frac{\sqrt{6}+\sqrt{2}}{2} = 2{\cdot}542$$

makes $\theta = 45^\circ$, and the Table has been checked by these values.

Also $b = \sqrt{3}$ makes $\theta = 75^\circ$.

At Quinquisection,

Region	I. $\infty > c > \sqrt{5}+2$	II. $\sqrt{5}+2 > c > 1$	III. $1 > c > \frac{\sqrt{5}-1}{2}$
$\frac{(c+3)(c^2-4c-1)}{20c^{\frac{1}{2}}\left(c-\frac{1}{c}+1\right)^{\frac{1}{2}}}$	$\frac{1}{\sqrt{\kappa'}}\ \mathrm{zn}\frac{4}{5}K$	$\mathrm{zn}\frac{1}{5}K$	
$\frac{(3c-1)(c^2-4c-1)}{20c^{\frac{1}{2}}\left(c-\frac{1}{c}+1\right)^{\frac{1}{2}}}$	$\frac{1}{\sqrt{\kappa'}}\ \mathrm{zn}\frac{2}{5}K$	$\mathrm{zn}\frac{3}{5}K$	
$\left[\frac{(c+1)(c-1)^5}{32c^5}\right]^{\frac{1}{4}}$	$\frac{\Theta\frac{4}{5}K}{\Theta 0}=C(18)$	$\sqrt{\kappa'}\frac{\Theta\frac{1}{5}K}{\Theta 0}=\sqrt{\kappa'}D(18)$	$\frac{H\frac{1}{5}K}{HK}=A(18)$
$\left[\frac{(c+1)^5(c-1)}{32c^5}\right]^{\frac{1}{4}}$	$\frac{\Theta\frac{2}{5}K}{\Theta 0}=D(36)$	$\sqrt{\kappa'}\frac{\Theta\frac{3}{5}K}{\Theta 0}=\sqrt{\kappa'}C(36)$	$\frac{H\frac{2}{5}K}{HK}=A(54)$ $=B(36)$

and so on, as in 'Phil. Trans.,' A, 1904, p. 264.

We find that $\theta=45°$ for

$$c=\left(\frac{5+\sqrt{5}}{2}\right)^{\frac{1}{2}}+\left(\frac{\sqrt{5}-1}{2}\right)^{\frac{1}{2}}+5^{\frac{1}{4}}+1=5{\cdot}184 \text{ in Region I,}$$

$$c=2\cos 18°+2\cos 36°=3{\cdot}5202 \text{ in Region II,}$$

$$c=\left(\frac{5-\sqrt{5}}{2}\right)^{\frac{1}{2}}+\left(\frac{\sqrt{5}+1}{2}\right)^{\frac{1}{2}}-5^{\frac{1}{4}}+1=0{\cdot}620 \text{ in Region III,}$$

and so obtain an independent verification of the entry in the Tables calculated from a series.

These verifications at the Division value are indicated in the Table by round brackets; values in heavy type have been completely verified.

Other Division values can be calculated algebraically to serve as a check at any stage of the calculation, and are analogous to the surd values of the circular functions of 45°, 30°, 60°, and the multiples of 18° and 15°; and it is possible to calculate all the tabular values for every 3° from an algebraical formula, by a method analogous to Euclid's construction of the quindecagon.

The entry is given in a Table to every 3° of the quadrant of K, and to four decimals only, as calculated from the first two terms of a q series. Discrepancy is apparent, and more terms are required at a high modular angle, $\theta = 75°$, as is seen by comparison with the exact numerical value in brackets.

But the Table is put forward for criticism of the arrangement, and further calculation is reserved.

The Committee invite criticism, and they are desirous of obtaining a suitable grant from the Association for the expense of their computations on these lines.

PART II.—*Bessel Functions.*

During the year the Committee have been fortunate in securing the valuable help of Mr. J. R. Airey, and they are desirous that his name be added to the Committee. Mr. Airey has calculated, to seven decimal places, the values, for a large range of the argument, of the functions

previously dealt with by Aldis and by B. A. Smith. The need for more extended tables of these functions has always been felt.

The tables mentioned in the Report of the previous year are not yet sufficiently advanced for publication, and in the meantime it seems desirable to publish Mr. Airey's tables in the present Report, since they are now complete enough in themselves. The whole of the work, of which an account is now given, is due to him.

Tables of the Neumann Functions $G_n(x)$ and $Y_n(x)$.

(A.)

The values of the functions $G_0(x)$ and $G_1(x)$ have been calculated by Aldis[1] to 21 decimal places from $x=0{\cdot}1$ to $6{\cdot}0$ by intervals of $0{\cdot}1$. In a paper by Michell on 'The Wave-resistance of a Ship,' tables of these functions in the form

$$\kappa J_0(x)-Y_0(x) \text{ and } \kappa J_1(x)-Y_1(x),$$

where

$$\kappa=\log 2-\gamma={\cdot}11593\ \ldots$$

were given by B. A. Smith[2] from $x=0{\cdot}00$ to $1{\cdot}00$ and from $1{\cdot}0$ to $10{\cdot}3$. The calculations were carried out to four places of decimals with an error of one in the last place and possibly of two when the value of x is greater than 3 or 4.

The following values of the $G_0(x)$ and $G_1(x)$ functions were calculated from the semiconvergent series

$$G_0(x)=-\sqrt{\frac{\pi}{2x}}\left\{P_0\sin\left(x-\frac{\pi}{4}\right)+Q_0\cos\left(x-\frac{\pi}{4}\right)\right\},$$

$$G_1(x)=\sqrt{\frac{\pi}{2x}}\left\{P_1\cos\left(x-\frac{\pi}{4}\right)-Q_1\sin\left(x-\frac{\pi}{4}\right)\right\},$$

and the results verified from the relation

$$G_1J_0-G_0J_1=\frac{1}{x}.$$

The G functions can also be calculated from the J functions, and this provides another method of verification :—

For large values of x,

$$J_0(x)=\sqrt{\frac{2}{\pi x}}\cdot\left\{P_0(x)\cos\left(x-\frac{\pi}{4}\right)-Q_0(x)\sin\left(x-\frac{\pi}{4}\right)\right\}$$

and

$$G_0(x)=-\sqrt{\frac{\pi}{2x}}\left\{P_0(x)\sin\left(x-\frac{\pi}{4}\right)+Q_0(x)\cos\left(x-\frac{\pi}{4}\right)\right\}$$

Put $Q_0(x)=R_0\sin\theta_0$ and $P_0(x)=R_0\cos\theta_0$.

Then

$\tan\theta_0=Q_0(x)\,/\,P_0(x)$ and θ_0 can be found.

Hence

$$G_0(x)=-\frac{\pi}{2}\cdot J_0(x)\cdot\tan\left(x-\frac{\pi}{4}+\theta_0\right).$$

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[1] Aldis, *Proc. Roy. Soc.*, lxvi., 1899-1900.

[2] Michell, *Phil. Mag.* [5], xlv., 1898.

Similarly,

$$G_1(x) = +\frac{\pi}{2} \, . \, J_1(x) \, . \, \cot\left(x - \frac{\pi}{4} + \theta_1\right),$$

where $$\tan \theta_1 = Q_1(x)/P_1(x).$$

The following interpolation formulæ may be used in connection with these tables, viz. :—

$$G_0(x \pm h) = \left\{ 1 - \frac{h^2}{2} \pm \frac{h^3}{6x} + \frac{h^4}{24}\left(1 - \frac{3}{x^2}\right) \ldots \right\} . \, G_0(x)$$

$$+ \left\{ \mp h + \frac{h^2}{2x} \pm \frac{h^3}{6}\left(1 - \frac{2}{x^2}\right) - \frac{h^4}{12x}\left(1 - \frac{3}{x^2}\right) \ldots \right\} . \, G_1(x),$$

$$G_1(x \pm h) = \left\{ 1 \mp \frac{h}{x} - \frac{h^2}{2}\left(1 - \frac{2}{x^2}\right) \pm \frac{h^3}{3x}\left(1 - \frac{3}{x^2}\right) + \frac{h^4}{24}\left(1 - \frac{6}{x^2} + \frac{15}{x^4}\right) \ldots \right\} . \, G_1(x)$$

$$+ \left\{ \pm h - \frac{h^2}{2x} \mp \frac{h^3}{6}\left(1 - \frac{3}{x^2}\right) + \frac{h^4}{24x}\left(2 - \frac{9}{x^2}\right) \ldots \right\} . \, G_0(x).$$

For comparison, it may be noted that $G_n(x)$ is the same as

$-\frac{\pi}{2}Y_n(x)$ [Nielsen], $-\frac{\pi}{2}K_n(x)$ [Graf u. Gubler],

$\frac{\pi}{2}Y_n(x)$ [Schafheitlin], and $-\frac{\pi}{2}N_n(x)$ [Jahnke u. Emde].

TABLE I.

Greatest error ·0000001.

x	$G_0(x)$	$G_1(x)$	x	$G_0(x)$	$G_1(x)$
0·1	+2·4099764	+10·1456967	2·8	0·6847352	−0·4139761
0·2	+1·6981963	+5·2210521	2·9	−0·6407463	−0·4648616
0·3	+1·2680624	+3·6020011	3·0	−0·5919546	0·5099974
0·4	+0·9519412	+2·7973873	3·1	−0·5389448	−0·5491967
0·5	+0·6982484	+2·3113834	3·2	−0·4823181	−0·5823120
0·6	+0·4846062	+1·9798181	3·3	−0·4226887	0·6092380
0·7	+0·2994958	+1·7329808	3·4	−0·3606789	−0·6299133
0·8	+0·1363487	+1·5364653	3·5	−0·2969150	−0·6443225
0·9	−0·0088409	+1·3715040	3·6	−0·2320223	−0·6524959
1·0	−0·1386337	+1·2271262	3·7	−0·1666211	−0·6545166
1·1	−0·2547254	+1·0966036	3·8	−0·1013215	0·6504898
1·2	−0·3582727	+0·9756787	3·9	−0·0367188	−0·6406022
1·3	−0·4500887	+0·8616128	4·0	+0·0266105	−0·6250602
1·4	−0·5307644	+0·7526423	4·1	+0·0881132	−0·6041189
1·5	−0·6007494	+0·6476529	4·2	+0·1472640	−0·5780732
1·6	−0·6604050	+0·5459743	4·3	+0·2035688	−0·5472556
1·7	−0·7100424	+0·4472469	4·4	+0·2565683	−0·5120335
1·8	−0·7499480	+0·3513320	4·5	+0·3058419	−0·4728055
1·9	−0·7804030	+0·2582480	4·6	+0·3510101	−0·4299980
2·0	−0·8016962	+0·1681262	4·7	+0·3917372	−0·3840617
2·1	−0·8141339	+0·0811766	4·8	+0·4277338	−0·3354674
2·2	−0·8180460	−0·0023370	4·9	+0·4587583	−0·2847016
2·3	−0·8137909	−0·0821170	5·0	+0·4846184	−0·2322629
2·4	−0·8017576	−0·1578477	5·1	+0·5051719	−0·1786568
2·5	−0·7823671	−0·2292077	5·2	+0·5203278	−0·1243919
2·6	−0·7560723	−0·2958808	5·3	+0·5300453	−0·0699752
2·7	−0·7233573	−0·3575642	5·4	+0·5343345	−0·0159079

TABLE I.—*Continued.*

x	$G_0(x)$	$G_1(x)$
5·5	+0·5332549	+0·0373194
5·6	+0·5269145	+0·0892301
5·7	+0·5154680	+0·1393663
5·8	+0·4991149	+0·1872925
5·9	+0·4780969	+0·2325990
6·0	+0·4526952	+0·2749056
6·1	+0·4232276	+0·3138641
6·2	+0·3900442	+0·3491624
6·3	+0·3535262	+0·3805244
6·4	+0·3140784	+0·4077157
6·5	+0·2721286	+0·4305415
6·6	+0·2281207	+0·4488507
6·7	+0·1825125	+0·4625354
6·8	+0·1357687	+0·4715324
6·9	+0·0883629	+0·4758218
7·0	+0·0407618	+0·4754287
7·1	−0·0065688	+0·4704202
7·2	−0·0531718	+0·4609071
7·3	−0·0986050	+0·4470397
7·4	−0·1424408	+0·4290079
7·5	−0·1842752	+0·4070381
7·6	−0·2237263	+0·3813912
7·7	−0·2604405	+0·3523587
7·8	−0·2940957	+0·3202622
7·9	−0·3244022	+0·2854469
8·0	−0·3511068	+0·2482808
8·1	−0·3739929	+0·2091495
8·2	−0·3928844	+0·1684534
8·3	−0·4076450	+0·1266023
8·4	−0·4181801	+0·0840132
8·5	−0·4244371	+0·0411053
8·6	−0·4264047	−0·0017028
8·7	−0·4241139	−0·0439995
8·8	−0·4176355	−0·0853815
8·9	−0·4070808	−0·1254585
9·0	−0·3925994	−0·1638571
9·1	0·3743773	−0·2002230
9·2	−0·3526337	−0·2342253
9·3	−0·3276212	−0·2655609
9·4	−0·2996198	−0·2939520
9·5	−0·2689370	−0·3191542
9·6	−0·2359018	−0·3409553
9·7	−0·2008649	−0·3591787
9·8	−0·1641908	−0·3736818
9·9	−0·1262564	−0·3843620
10·0	−0·0874480	−0·3911526
10·1	−0·0481436	−0·3940261
10·2	−0·0087733	−0·3929909
10·3	+0·0303139	−0·3880964
10·4	+0·0687201	−0·3794266
10·5	+0·1060764	−0·3671018
10·6	+0·1420237	−0·3512762
10·7	+0·1762211	−0·3321368
10·8	+0·2083479	−0·3099008
10·9	+0·2381063	−0·2848144
11·0	+0·2652257	−0·2571470
11·1	+0·2894597	−0·2271953
11·2	+0·3105979	−0·1952699
11·3	+0·3284589	−0·1617012
11·4	+0·3428950	−0·1268323
11·5	+0·3537937	−0·0910159
11·6	+0·3610784	−0·0546110
11·7	+0·3647084	−0·0179793
11·8	+0·3646789	+0·0185178
11·9	+0·3610210	+0·0545247
12·0	+0·3538020	+0·0896913
12·1	+0·3431221	+0·1236796
12·2	+0·3291161	+0·1561661
12·3	+0·3119493	+0·1868435
12·4	+0·2918171	+0·2154260
12·5	+0·2689428	+0·2416485
12·6	+0·2435740	+0·2652730
12·7	+0·2159819	+0·2860869
12·8	+0·1864566	+0·3039080
12·9	+0·1553051	+0·3185840
13·0	+0·1228486	+0·3299050
13·1	+0·0894179	+0·3380535
13·2	+0·0553523	+0·3427052
13·3	+0·0209911	+0·3439302
13·4	−0·0132827	+0·3417416
13·5	−0·0472449	+0·3361863
13·6	−0·0804483	+0·3273439
13·7	−0·1126076	+0·3153250
13·8	−0·1434122	+0·3002710
13·9	−0·1725664	+0·2823520
14·0	−0·1997937	+0·2617651
14·1	−0·2248377	+0·2387317
14·2	−0·2474666	+0·2134960
14·3	−0·2674724	+0·1863226
14·4	−0·2846758	+0·1574914
14·5	−0·2989253	+0·1273006
14·6	−0·3101008	+0·0960550
14·7	−0·3181120	+0·0640708
14·8	−0·3229008	+0·0316683
14·9	−0·3244424	−0·0008300
15·0	−0·3227425	−0·0331024
15·1	−0·3178400	−0·0648324
15·2	−0·3098044	−0·0957100
15·3	−0·2987362	−0·1254361
15·4	−0·2847652	−0·1537274
15·5	−0·2680484	−0·1803057
15·6	−0·2487694	−0·2049274
15·7	−0·2271358	−0·2273590
15·8	−0·2033775	−0·2473930
15·9	−0·1777434	−0·2648464
16·0	−0·1504996	−0·2795630

(B.)

From the simple relation between the G, J, and Y functions, viz.,

$$Y_n(x)=(\log 2-\gamma)J_n(x)-G_n(x),$$

the values of the Neumann functions $Y_0(x)$ and $Y_1(x)$ are readily obtained. Tables of the functions were calculated to four places of decimals by Smith with a possible error of two in the last figure.[3]

For purposes of interpolation formulæ similar to those for $G_0(x)$ and $G_1(x)$ may be used.

TABLE II.

Greatest error ·0000001.

x	$Y_0(x)$	$Y_1(x)$	x	$Y_0(x)$	$Y_1(r)$
0·1	−2·2943346	−10·1399073	5·0	−0·5052074	+0·1942862
0·2	−1·5834212	−5·2095168	5·1	−0·5219048	+0·1395766
0·3	−1·1547248	−3·5848063	5·2	−0·5331139	+0·0846015
0·4	−0·8406008	−2·7746616	5·3	−0·5388333	+0·0298674
0·5	−0·5894502	−2·2832969	5·4	−0·5391120	−0·0241284
0·6	−0·3788761	−1·9465804	5·5	−0·5340483	−0·0769028
0·7	−0·1973369	−1·6948399	5·6	−0·5237877	−0·1279898
0·8	−0·0382373	−1·4937049	5·7	−0·5085214	−0·1769452
0·9	+0·1024584	−1·3244417	5·8	−0·4884837	−0·2233504
1·0	+0·2273442	−1·1761105	5·9	−0·4639494	−0·2668153
1·1	+0·3381522	−1·0420112	6·0	−0·4352307	−0·3069820
1·2	+0·4360782	−0·9179113	6·1	−0·4026739	−0·3435269
1·3	+0·5219762	−0·8010938	6·2	−0·3666552	−0·3761647
1·4	+0·5964808	−0·6898135	6·3	−0·3275793	−0·4046482
1·5	+0·6600864	−0·5829705	6·4	−0·2858710	−0·4287732
1·6	+0·7132005	−0·4799054	6·5	−0·2419754	−0·4483766
1·7	+0·7561814	−0·3802657	6·6	−0·1963504	−0·4633398
1·8	+0·7893631	−0·2839159	6·7	−0·1494645	−0·4735886
1·9	+0·8130747	−0·1908736	6·8	−0·1017897	−0·4790933
2·0	+0·8276522	−0·1012656	6·9	−0·0538035	−0·4798680
2·1	+0·8334489	−0·0152936	7·0	−0·0059732	−0·4759716
2·2	+0·8308405	+0·0667906	7·1	+0·0412383	−0·4675041
2·3	+0·8202297	+0·1447052	7·2	+0·0873798	−0·4546088
2·4	+0·8020483	+0·2181536	7·3	+0·1320184	−0·4374072
2·5	+0·7767579	+0·2868366	7·4	+0·1747389	−0·4162989
2·6	+0·7448496	+0·3504635	7·5	+0·2151524	−0·3913585
2·7	+0·7068429	+0·4087597	7·6	+0·2528949	−0·3629333
2·8	+0·6632837	+0·4614743	7·7	+0·2876333	−0·3313388
2·9	+0·6147415	+0·5083855	7·8	+0·3190683	−0·2969186
3·0	+0·5618064	+0·5493050	7·9	+0·3469349	−0·2600377
3·1	+0·5050853	+0·5840829	8·0	+0·3710065	−0·2210791
3·2	+0·4451982	+0·6126099	8·1	+0·3910948	−0·1804440
3·3	+0·3827739	+0·6348198	8·2	+0·4070530	−0·1385432
3·4	+0·3184456	+0·6506912	8·3	+0·4187751	−0·0957947
3·5	+0·2528462	+0·6602489	8·4	+0·4261976	−0·0526205
3·6	+0·1866039	+0·6635634	8·5	+0·4292992	−0·0094419
3·7	+0·1203377	+0·6607516	8·6	+0·4281000	+0·0333237
3·8	+0·0546525	+0·6519762	8·7	+0·4226621	+0·0752684
3·9	−0·0098655	+0·6374438	8·8	+0·4130871	+0·1159960
4·0	−0·0726527	+0·6174037	8·9	+0·3995159	+0·1551257
4·1	−0·1331723	+0·5921463	9·0	+0·3821269	+0·1922965
4·2	−0·1909188	+0·5619996	9·1	+0·3611334	+0·2271690
4·3	−0·2454214	+0·5273274	9·2	+0·3367803	+0·2594298
4·4	−0·2962467	+0·4885254	9·3	+0·3093440	+0·2887952
4·5	−0·3430029	+0·4460183	9·4	+0·2791264	+0·3150089
4·6	−0·3853418	+0·4002555	9·5	+0·2464545	+0·3378498
4·7	−0·4229611	+0·3517075	9·6	+0·2116746	+0·3571306
4·8	−0·4556067	+0·3008619	9·7	+0·1751518	+0·3727008
4·9	−0·4830736	+0·2482186	9·8	+0·1372627	+0·3844449

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[3] Smith, *Messenger of Mathematics*, 1897.

TABLE II.—*Continued.*

x	$Y_0(x)$	$Y_1(x)$	x	$Y_0(x)$	$Y_1(x)$
9·9	+0·0983933	+0·3922882	13·0	−0·0988593	−0·3381471
10·0	+0·0589363	+0·3961925	13·1	−0·0647374	−0·3437170
10·1	+0·0192732	+0·3961587	13·2	−0·0302316	−0·3458431
10·2	−0·0201652	+0·3922239	13·3	+0·0043165	−0·3445304
10·3	−0·0590321	+0·3844657	13·4	+0·0385241	0·3398172
10·4	−0·0969345	+0·3729956	13·5	+0·0721689	−0·3317752
10·5	−0·1335114	+0·3579606	13·6	+0·1048094	−0·3205080
10·6	−0·1684138	+0·3395406	13·7	+0·1361673	−0·3061498
10·7	0·2013136	+0·3179468	13·8	+0·1659418	−0·2888644
10·8	−0·2319054	0·2934192	13·9	+0·1938491	−0·2688437
10·9	−0·2599086	+0·2662248	14·0	+0·2196265	−0·2463027
11·0	0·2850720	+0·2366520	14·1	+0·2430335	−0·2214829
11·1	−0·3071704	+0·2050143	14·2	+0·2638557	0·1946443
11·2	0·3260159	+0·1716369	14·3	+0·2819044	−0·1660660
11·3	−0·3414512	+0·1368628	14·4	+0·2970207	−0·1360404
11·4	−0·3533537	+0·1010433	14·5	+0·3090745	−0·1048760
11·5	−0·3616369	+0·0645397	14·6	+0·3179684	−0·0728858
11·6	−0·3662508	+0·0277148	14·7	+0·3236352	−0·0403916
11·7	−0·3671814	0·0090675	14·8	+0·3260405	−0·0077174
11·8	−0·3644508	−0·0454469	14·9	+0·3251834	+0·0248135
11·9	−0·3581170	−0·0810711	15·0	+0·3210934	+0·0568804
12·0	0·3482733	−0·1155959	15·1	+0·3138332	+0·0881706
12·1	−0·3350455	−0·1486917	15·2	+0·3034953	+0·1183709
12·2	−0·3185930	−0·1800459	15·3	+0·2902029	+0·1472173
12·3	−0·2991043	−0·2093642	15·4	+0·2741069	+0·1744069
12·4	−0·2767969	−0·2363760	15·5	+0·2553851	+0·1996910
12·5	0·2519143	−0·2608333	15·6	+0·2342402	+0·2228318
12·6	−0·2247227	−0·2825169	15·7	+0·2108972	+0·2436150
12·7	−0·1955098	0·3012348	15·8	+0·1856022	+0·2618487
12·8	−0·1645802	−0·3168264	15·9	+0·1586181	+0·2773702
12·9	−0·1322530	−0·3291626	16·0	+0·1302233	+0·2900429

Magnetic Observations at Falmouth Observatory.—Report of the Committee, consisting of Sir W. H. PREECE *(Chairman)*, Dr. W. N. SHAW *(Secretary)*, Professor W. G. ADAMS, Dr. CHARLES CHREE, Captain CREAK, Mr. W. L. FOX, Dr. R. T. GLAZEBROOK, Sir A. W. RÜCKER, *and* Professor A. SCHUSTER.

THE usual number of absolute observations has been made by Mr. Kitto.

The mean values of the magnetic elements for the year 1910 are as follows:—

Declination	17° 41′·6 W.
Inclination	66° 29′·0 N.
Horizontal force	0·18802 C.G.S.
Vertical force	0·43208 C.G.S.

The declination, horizontal force, and vertical force curves have been tabulated as usual for the Astronomer-Royal's five quiet days a month, and the usual tables of hourly means and diurnal inequalities have appeared in the 'Report of the Observatory Committee of the Royal Cornwall Polytechnic Society for the year 1910' and in the

'Summaries of Results of Geophysical and Meteorological Observations, 1910,' published by the Meteorological Office in continuation of the reports of the Observatory Department of the National Physical Laboratory.

A few days of horizontal force trace were lost owing to the breaking—in the end of October—of the suspension of the horizontal force magnet, which had been in use since 1891. Some difficulty was experienced in dealing with the November quiet day records of this element, owing to a tendency in the trace to drift for some time after the new suspension was fixed. It was, however, found possible, with the guidance afforded by the Kew curves, to surmount this difficulty, except for the first quiet day of the month.

The magnetic character of individual days has been decided by Mr. Kitto as in the previous year, and communicated to Dr. van Everdingen of de Bilt for inclusion in the International List

The magnetographs at Eskdalemuir have now been arranged to record directly the variations in the Northerly, Westerly, and Vertical components of the magnetic force. Regular tabulation of the curves commenced with January 1, 1911.

Since 1901 the magnetic work at Falmouth has been maintained by grants to the Royal Cornwall Polytechnic Society from the British Association and the Government Grant Committee amounting to 100*l.* a year. The grounds put forward for the grants in 1901 and subsequent years were the notification by the Society that unless pecuniary aid were forthcoming the work must cease, and the representation on the part of those interested in Terrestrial Magnetism that the instruments at Kew had been disturbed by electric tramways, that the new observatory at Eskdalemuir was not yet ready to take its place, and that the maintenance of continuous records from undisturbed instruments during the transition period was of special importance.

The observatory at Eskdalemuir is now in operation, and the period of transition must be regarded as coming to an end when the results for the first year of the new observatory are published in 1912.

So far as the observatory at Falmouth is concerned the situation reverts to the position of 1901. The Society have no funds for the observatory beyond the 250*l.* a year contributed by the Meteorological Office for the maintenance of a meteorological station of the first order, and it may be remarked that that sum, even when augmented by 100*l.* a year for magnetic observations, is not properly adequate for the maintenance of a separate institution with a scientific staff. The withdrawal of the grant for magnetic work would therefore have consequences beyond the suspension of the magnetic records.

The Society have been responsible for the maintenance of the observatory since 1868 and for the magnetic work since 1887. They have provided a site and building for these purposes, and are naturally anxious that the work should be continued. They are desirous of making an appeal to Government for funds for the purpose if they have the necessary support on scientific grounds.

The Committee recognise the advantage of having a magnetic observatory in the South of England undisturbed by electric trams. And

this advantage might well be secured by arranging for a continuance of the magnetic work at Falmouth, at least so long as Falmouth remains undisturbed. There is also a special advantage in having an observatory on the coast so that it may be directly available for comparisons with observations at sea, and the position of the Falmouth Observatory is very convenient from this point of view. The situation of the observatory with reference to the growing town of Falmouth is subject to some disadvantages owing to the mechanical disturbances due to road traffic. This is a point which would come up for consideration with the appeal which the Polytechnic Society propose. In the meantime the Committee desire to support the appeal, and in asking the Association to continue its support of the magnetic observations for another year, until the first year's results of the Eskdalemuir Observatory are published, they understand that by that time, and before the next meeting of the Association, the result of the appeal for the maintenance of Falmouth Observatory as a permanent institution will have been ascertained. They therefore recommend their reappointment with a grant of 50*l.*

Experiments for Improving the Construction of Practical Standards for Electrical Measurements.—Report of the Committee, consisting of Lord RAYLEIGH (*Chairman*), Dr. R. T. GLAZEBROOK (*Secretary*), Professors J. PERRY, W. G. ADAMS, *and* G. CAREY FOSTER, Sir OLIVER LODGE, Dr. A. MUIRHEAD, Sir W. H. PREECE, Professors A. SCHUSTER, J. A. FLEMING, *and* Sir J. J. THOMSON, Dr. W. N. SHAW, Dr. J. T. BOTTOMLEY, Rev. T. C. FITZPATRICK, Professor S. P. THOMPSON, Mr. J. RENNIE, Principal E. H. GRIFFITHS, Sir ARTHUR RÜCKER, Professor H. L. CALLENDAR, *and* Messrs. G. MATTHEY, T. MATHER, *and* F. E. SMITH.

THE Committee have to regret the death, since the last meeting of the Association, of Dr. G. Johnstone Stoney, F.R.S. He had been a member since 1861, and up to a few years since continued his active interest in the work. In its earlier stages his skill in definition and his admirable choice of nomenclature had proved invaluable to the Committee. The collected Reports which are to be issued shortly will indicate how large a share in the establishment of the C.G.S. system of units is due to him.

Republication of Reports.—The republication of the Reports is not yet completed, but this should be done within the present year. The proofs of the Reports from 1862 to 1883 have been finally revised and the remaining proofs will soon be ready.

Lorenz Apparatus.—The progress made has been satisfactory. Preliminary experiments have shown that the apparatus is uninfluenced by changes in the earth's magnetic field and that the thermal E.M.F.S at the brushes on the two discs very nearly balance. With the form of brush in use at present there are sudden changes in the

difference of the thermal E.M.F.s amounting to 2×10^7 volt, and it may be difficult entirely to eliminate these. With other forms of brushes, *e.g.*, those made of gauze, the difference was often 1,000 times as great. It was this difficulty which led Lord Rayleigh in 1883 to amalgamate the edge of the disc, and as a further improvement Professor Viriamu Jones and Professor Ayrton used mercury jets instead of brushes. Since in the present apparatus the changes are only 1 in 10,000 of the difference of potential produced in one arrangement of the brushes and less for a second arrangement, it is hoped that mercury contacts will not be necessary. Further experiments will be made in order to obtain greater perfection if such is possible.

Resistance Standards.—The construction of new mercury standards of resistance in accordance with the specification of the London Conference is being proceeded with, and some of the standards will be completed this year. Similar work is in progress in France, in Germany, in Austria, and in the United States. In the latter country four standards have had all of their constants determined, and the resistance unit so obtained is in very close agreement with that obtained from the old National Physical Laboratory standards.

In the Committee's Report for 1908 it was shown that many manganin resistance coils—some of which were purchased by the Committee in 1895—were very changeable in resistance, and in consequence frequent comparison with mercury standards was necessary. In 1908 it was shown at the Bureau of Standards, and confirmed at the National Physical Laboratory and at the Reichsanstalt, that these changes were largely due to the effect of moisture on the shellac covering the wire. To eliminate this source of trouble, many of the coils were hermetically sealed in 1909, and it is satisfactory to record that they are now much more constant. The importance of this hermetical sealing is so great when manganin resistances are to be sent to such places as cable stations in the tropics that the attention of instrument manufacturers is drawn to the matter. Standard coils are readily sealed and boxes of coils may be sealed in metal cases. The following figures for standard coils of manganin show the advantage of hermetical sealing:—

Nominal value		100 ohms		1,000 ohms	10,000 ohms
		No. 2450	No. 740	No. 2449	No 2448
Open coils	Oct. 1903	$99{\cdot}995_0$	$1{,}000{\cdot}15_3$	$1{,}000{\cdot}01_2$	$10{,}000{\cdot}2_4$
	1904	$100{\cdot}000_2$	$\cdot17_2$	$\cdot24_4$	$2{\cdot}4_0$
	1905	$\cdot004_8$	$\cdot21_8$	$\cdot49_4$	$3{\cdot}5_7$
	1906	$\cdot009_1$	$\cdot24_8$	$\cdot66_8$	$3{\cdot}8_2$
	1907	$\cdot013_2$	$\cdot26_8$	$\cdot81_4$	$3{\cdot}7_4$
	1908	$\cdot028_8$	$\cdot30_1$	$1{\cdot}13_0$	$3{\cdot}8_5$
Hermetically sealed in paraffin oil	June 1909	$\cdot036_9$	$\cdot36_5$	$1{\cdot}04_6$	$5{\cdot}5_3$
	1910	$\cdot038_1$	$\cdot35_7$	$1{\cdot}07_5$	$5{\cdot}5_5$
	1911	$\cdot039_0$	$\cdot35_0$	$1{\cdot}06_0$	$5{\cdot}6_1$

It will be noted that the changes during the last three years are very small.

Silver Voltameter and Standard Cell.—Although the actions which take place when a current passes through a solution of silver nitrate as in a silver voltameter are now well understood, the effects of septa —such as silk, filter paper, and porous porcelain—are by no means clear, and experiments have, therefore, been made to decide whether any septum at all should be used in a voltameter. Such experiments were suggested at the Washington Meeting in 1910. The results of the experiments made at the National Physical Laboratory indicate that a septum of any kind is usually a source of trouble, and may produce secondary reactions during the electrolysis which affect the weight of the silver deposit. Fortunately, voltameters have been designed which render a septum unnecessary, and these may be useful not only in precise current measurements with the silver voltameter but for the deposition of metals other than silver.

The reproducibility and constancy of the Weston normal cell are still being carefully examined. The chief anomaly is the hysteresis effect mentioned in last year's Report: for this effect we have no explanation although one is much needed, as probably it would enable cells to be made so as to remain even more constant in E.M.F. than at present. It is necessary to point out that while the effect is called a hysteresis one, the E.M.F. does not lag behind the temperature. Briefly put, with ascending temperatures the E.M.F. changes in close agreement with the temperature—E.M.F. formula, but with descending temperatures the E.M.F. changes too rapidly, corresponding to values at temperatures lower than the temperature of the cell, by from 3° to 15°.

The Committee had hoped to have made this their last Report, but in view of the fact that the republication is not complete they ask for reappointment, with Lord Rayleigh as Chairman and Dr. R. T. Glazebrook as Secretary.

The Study of Isomorphous Sulphonic Derivatives of Benzene.—Report of the Committee, consisting of Principal MIERS (*Chairman*), *and* Professors H. E. ARMSTRONG (*Secretary*), W. J. POPE, *and* W. P. WYNNE.

IN the previous report it was stated that the crystallographic study of the various derivatives of 1:4 di-derivatives of benzenesulphonic acid containing halogens had been carried so far that it had been possible to publish the results obtained in the case of twenty-nine such compounds and that these results found a ready interpretation in the Barlow-Pope theory correlating molecular structure with crystalline form.

During the past year considerable progress has been made with the morphological study of other benzenesulphonic derivatives. Many derivatives of benzenesulphonic acid have been examined crystallographically, including the anilide and several toluidides and xylidides.

In addition, a number of the derivatives of benzenesulphonic acid

containing halogens in the para-position have been similarly examined; also derivatives of the three isomeric benzenedisulphonic acids.

In almost every case the crystal structure of these compounds can be successfully interpreted in the light of the Barlow-Pope theory.

A second memoir embracing the results of the investigation is now in course of preparation.

The Committee desire to express their thanks especially to Messrs. Colgate and Rodd and also to Mr. Mummery for the assistance they have rendered in the inquiry during the year.

The Influence of Carbon and other Elements on the Corrosion of Steel.—Report of the Committee, consisting of Professor J. O. ARNOLD (*Chairman*), Dr. W. E. S. TURNER (*Secretary*), Professor W. P. WYNNE, Professor A. McWILLIAM, Mr. C. CHAPPELL, *and* Mr. F. HODSON.

THE subject of the corrosion of iron and steel is one that is rapidly engaging considerable attention in the metallurgical world, the researches of Friend, Cushman, Walker, Longmuir, and others having brought it deservedly into considerable prominence. Despite the fact, however, that the modern metallurgy of iron and steel largely centres about the influence of various alloying elements upon its physical and mechanical properties, no reliable data are available as to the influence exerted by them upon its corrodibility. In view of the absence of such data regarding the influence of carbon, in gradually ascending percentages, upon the corrodibility of iron, and especially in view of the fundamental importance of carbon as an iron-alloying element, the Committee have confined their attention solely, during the past year, to the investigation of the influence exerted by this element upon the corrodibility of iron.

An attempt was made by Andrews[1] to obtain some data regarding this question, and his results were published in 1885 in a paper on 'The Corrosion of Metals during Long Exposure in Sea-water' one of a series of brilliant and systematic researches on corrosion which are unfortunately not so well known as they deserve to be. His ascending carbon series, however, included such widely diverse materials as Wrought Iron, Siemens and Bessemer Steels, and also Crucible Cast Steels, in which the percentages of Si and Mn vary considerably, rising as high as 0·4 per cent. and 1·3 per cent. respectively, whilst the S and P in some cases respectively reach such abnormal figures as 0·12 per cent. and 0·27 per cent. each. The values given by such a series can hardly be relied upon as being indicative of the influence of carbon alone upon the corrodibility of iron.

A series of pure iron-carbon alloys have, therefore, been obtained by the Committee in order not only to indicate the influence of carbon upon the corrodibility and other properties of iron but to serve also

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[1] *Proc. Inst. Civil Eng.*, vol. 82, p. 281.

as a base line from which the influence of other elements upon the corrodibility of steel may be determined in future researches. These pure iron-carbon alloys were prepared by the coke crucible process in the Metallurgical Department of Sheffield University, the materials employed being Swedish bar iron and charcoal, this method having been found to give the purest iron-carbon alloys obtainable. Six such alloys have been employed, ranging from 0·10 per cent. to 0·96 per cent. carbon, and the microscopic examination in the rolled condition showed the distribution of the micro-constituents in these steels to be remarkably even throughout the whole of the series. It is also important to note that, despite careful search, no traces were found of manganese sulphide, the powerfully electropositive nature of which tends to cause serious electrolytic action when present in steel, thus materially increasing the corrodibility.

The determinations of the corrodibility and other properties of these steels have been carried out in several states of heat treatment, which have been designed to resolve the pearlite into the principal varieties in which it usually exists in carbon steels—viz.: (*a*) Diffused (*b*) Laminated, and (*c*) Emulsified, and also into Hardenite, which is the essential constituent of hardened carbon steels. The treatments employed were (1) As Rolled, (2) Normalised, (3) Annealed, (4) and (5) Hardened and Tempered at (α) 400° C. and (β) 500° C., (6) Hardened.

Determination of Simple Corrosion in Sea-water.

The relative corrodibilities of these steels in all states of treatment have been measured by immersing polished cylindrical bars of the various specimens ($4\frac{1}{2}$ inches long × $\frac{5}{8}$ inches dia.), each separately in 700 c.c. sea-water for a period of thirteen weeks, the loss in weight per cent. during this period being determined.

The results obtained, as plotted in fig. 1, indicate that the carbon exerts two types of influence upon the corrodibility, dependent upon the condition of the carbide in the steel. In the rolled, normalised, and annealed specimens, in which the carbide (as shown by microscopic examination) exists entirely either as the diffused normal variety, or as the laminated variety of pearlite, the corrodibility rises to a maximum at saturation point (0·89 per cent. carbon), and then decreases upon the appearance of cementite in the steel. The rise in corrodibility in such steels with increase of carbon from 0·10 per cent. to 0·89 per cent. is not regular, but is much more rapid in the range 0·3 per cent. to 0·89 per cent. carbon than in the low carbon range 0·10 per cent. to 0·3 per cent. carbon.

In the hardened and tempered specimens, however, in which the carbide has been converted respectively either to hardenite or the emulsified variety of pearlite, it has been found that the corrodibility rises continuously from 0·10 per cent. to 0·96 per cent. carbon, no maximum being observed at the saturation point. The proportional increase of corrodibility in these steels with rise of carbon per cent. is very rapid up to about 0·25 per cent. carbon in the case of the hardened steels, and about 0·40 per cent. carbon in the tempered

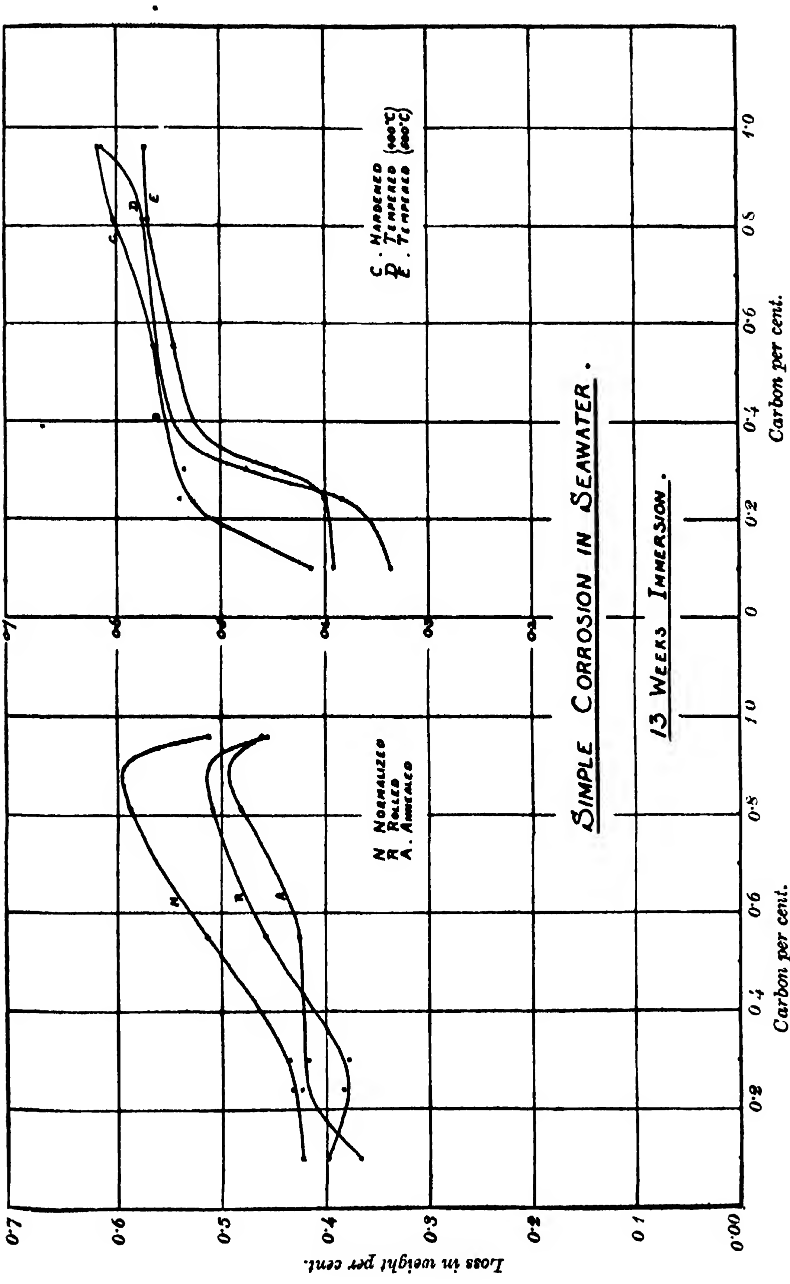
SIMPLE CORROSION IN SEAWATER.
13 WEEKS IMMERSION.
N NORMALIZED
R ROLLED
A. ANNEALED
N
R
A
C. HARDENED
D. TEMPERED (100°C)
E. TEMPERED (200°C)
C
D
E
Loss in weight per cent.
0·7
0·6
0·5
0·4
0·3
0·2
0·1
0·00
Carbon per cent.
0·2
0·4
0·6
0·8
1·0
0
Carbon per cent.

FIG. 1.

specimens. After these points the rate of increase of corrodibility with rise of carbon per cent. is small but regular up to 0·96 per cent. carbon, being in this respect the reverse of that found in the type first described.

The state of division of the carbide in the pearlite is found to exert very considerable influence on the rate of corrosion of iron-carbon alloys. In general, the annealed steels, in which the carbide exists entirely in the laminated condition, show a minimum corrodibility, whilst the tempered steels containing the carbide as the emulsified variety show a maximum corrodibility—except in the very low carbon steels. The normalised steels, moreover, in which the carbide is in an intermediate state of division, being mainly of the diffused variety, take up an intermediate position. This indicates that the finer the state of division of the carbide in the pearlite, the greater is the liability to corrosion when immersed in sea-water—a conclusion which is in complete accordance with the electrolytic theory advanced by Cushman [2] and Walker.[3] This is also supported by the fact that in the case of tempered steels a rise in the tempering temperature from 400° C. to 500° C. produces a marked decrease in the corrodibility, this no doubt being due to the slight decrease in the fineness of division of the pearlite which is produced by the rise in tempering temperature The conversion of the pearlite into hardenite is accompanied by a very considerable rise in corrodibility, the hardened steels corroding more rapidly than any of the unhardened or tempered steels.

Careful examination of the deposits on the corroded bars on removing them from the sea-water shows the rust deposit to be made up of two different types. These may be briefly described as

(*a*) Light brown deposit, flocculent and easily removed, forming an even coating over the whole of the exterior of the rust deposit.

(*b*) A deposit of bluish-black colour, somewhat greenish in some cases, underlying the previous mentioned deposit. This is mainly found at the lower end of the bars, to which it is usually somewhat firmly adherent. In the case of the hardened and tempered specimens a thin easily removed layer of a similar colour is found covering the whole of the bar underneath deposit (*a*), in addition to the firmly adherent deposit at the lower end. Whether this deposit is merely a form of deposit (*b*), or whether it is really a chemically different type of deposit of the same colour, is not known. A detailed examination of these respective deposits might probably throw considerable light on the phenomena involved in the corrosion of steel.

Determination of Solution Pressures in Sea-water.

Determinations of the solution pressures of the steels after prolonged immersion in sea-water have also been made with a view to ascertaining the influence of carbon on the electro-chemical positions of the various steels under conditions of galvanic corrosion. The results up to the present, however, are not sufficiently conclusive to warrant any definite statements in this direction being made in this report.

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[2] *Journ. Iron and Steel Inst.*, 1909, vol. 1, p. 33.

[3] *Ibid.*, 1909, vol. 1, p. 69.

The influence of the condition of the carbide upon the relative electrochemical positions of the steels is, however, more definitely shown. In the case of a saturated steel it is found that after three weeks' immersion in sea-water the emulsified variety of pearlite is electropositive to the diffused and laminated varieties, whilst the conversion of the pearlite into hardenite renders it electronegative in this form to all the varieties of pearlite.

Determination of Solubility in Acid Solutions.

The solubilities of the various steels employed have been determined in 1 per cent. solutions of H_2SO_4 and HCl, in order to determine the influence of carbon on the solubility of iron-carbon alloys, and also to obtain an indication of the loss in weight per cent. sustained on immersion in acid solutions, as contrasted with corrosion in such solutions as sea-water.

This was considered of importance in view of corrosion taking place under ordinary conditions, especially in large towns, where atmospheric acids contained in the rainwater play an important part. This section is also of interest in the case of corrosion taking place in such solutions as acid pit waters.

The solubility tests were carried out on polished cylindrical bars of the steels (1½ inch long × ⅜ inch dia.), which were separately immersed for a period of forty-eight hours in 100 c.c. of the acid employed. The results obtained on immersion in 1 per cent. H_2SO_4 are remarkably similar to those obtained in 1 per cent. HCl, both as regards the actual values obtained with given specimens and in the type of influence exerted upon the solubility by the carbon per cent. and the treatment. The two sets are consequently dealt with together, and the curves obtained with 1 per cent. H_2SO_4 only are shown in fig. 2. It may be noted that the practice of drawing smooth curves through the experimentally determined points has been adopted throughout in preference to the direct joining-up of these points by straight lines, as is sometimes carried out. The method adopted is found, in this case, to give much more satisfactory indications of the real positions of the critical points in the curve than the alternative one, whilst the possible degree of error introduced thereby is sufficiently small to be negligible.

The influence of carbon on the solubility is found to vary considerably according to the treatment previously undergone by the steel.

In the normalised, rolled, and annealed specimens the solubility rises very rapidly from 0·10 per cent. up to 0·22 per cent., carbon approx., after which it falls abruptly, reaching a minimum at about 0·30 per cent. to 0·40 per cent. carbon. Further rise of carbon from 0·40 per cent. to 0·96 per cent. carbon produces a general, but somewhat irregular, rise in solubility in the normalised and rolled specimens, whilst in the annealed specimens a maximum solubility is reached at 0·60 per cent. carbon, after which the values gradually decrease again to 0·96 per cent. carbon. A comparison of these curves with those given by Heyn and Bauer[4] as indicative of the probable influence

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[4] *Journ. Iron and Steel Inst.*, 1909, vol. 1, p. 109.

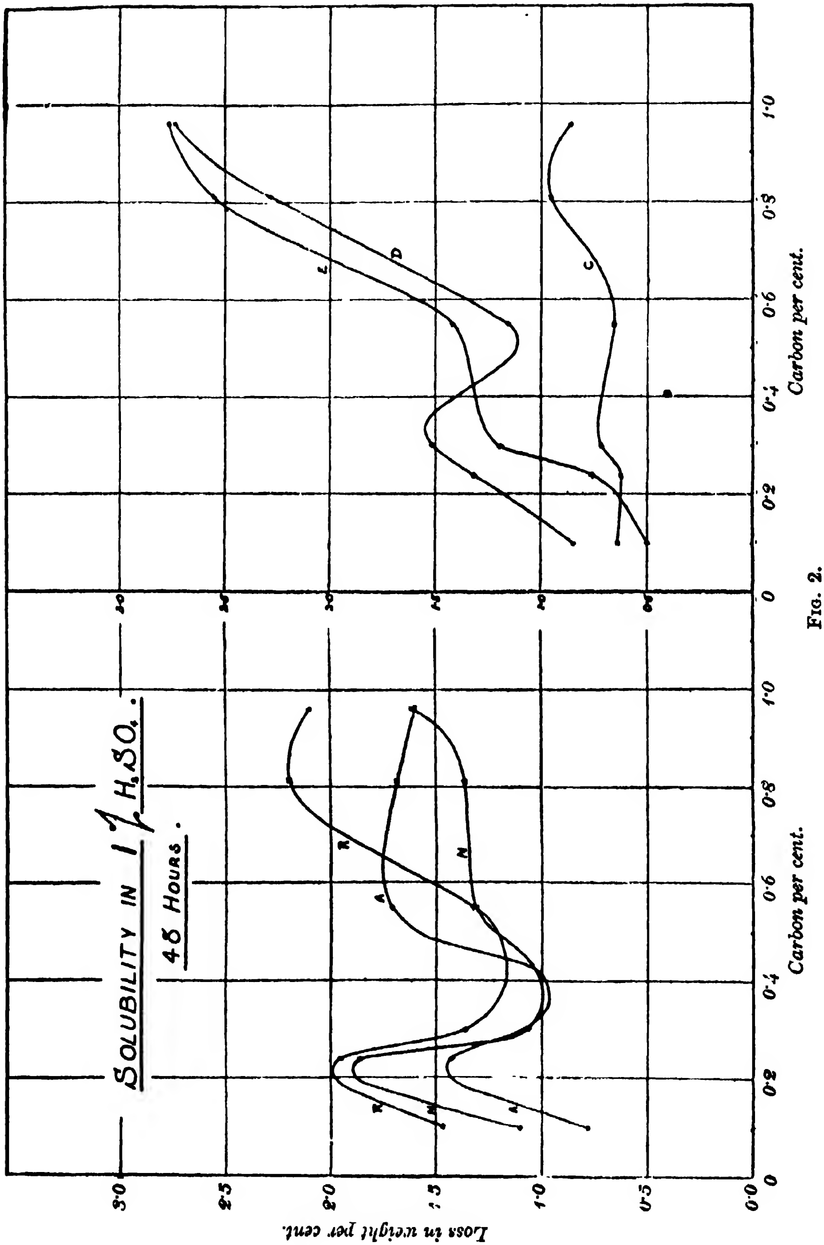

SOLUBILITY IN 1% H₂SO₄.
48 HOURS.
3·0
2·5
2·0
1·5
1·0
0·5
0·0
Loss in weight per cent.
0
0·2
0·4
0·6
0·8
1·0
Carbon per cent.
R
N
A
L
D
C

FIG. 2.

of carbon percentage upon the solubility in 1 per cent. H_2SO_4 reveals very important differences. In the curves given by these experimenters no peak is observed at 0·22 per cent. carbon owing to the absence of any steels between 0·14 per cent. and 0·30 per cent. carbon, and it is interesting to observe that in the absence of the intermediate steel (0·24 per cent. carbon) in this series, the abrupt peak at 0·22 per cent. carbon would have been entirely eliminated. In connection with this point it may be well to remark that careful microscopic examination fails to reveal any abnormalities in any of the microstructures of the steels employed in this range of composition. A more important divergence, however, arises in the suggestion by these authors that the maximum solubility occurs at a 'medium proportion of carbon'—presumably about 0·4 per cent. to 0·5 per cent. carbon. This is completely negatived by these results, and in view of the fact that the steels employed by Heyn and Bauer in this range of carbon percentage also contain over 1 per cent. Mn, it appears probable that this factor has exerted much more influence than was supposed by the authors themselves.

The tempered steels show a rapid rise in solubility with rise of carbon from 0·10 per cent. to 0·30 per cent. This rise is followed by a range from 0·30 per cent. to 0·55 per cent. carbon, in which the solubility remains constant in the case of the specimens tempered at 500° C., and decreases in that of the specimens tempered at 400° C. After 0·55 per cent. carbon a very rapid and regular rise in solubility occurs with rise of carbon to 0·96 per cent., the values given in the latter half of this range being higher than those given by steels of any other composition or treatment.

In the case of the hardened steels, the carbon tends to exert a similar type of influence to that described in the steels tempered at 400° C., this fact being more evident in the 1 per cent. HCl results than in the 1 per cent. H_2SO_4 results shown. The variations with carbon percentage, however, are very much less pronounced, and the total rise in solubility from 0·10 per cent. to 0·96 per cent. carbon is very small. In connection with the influence exerted by the condition of the carbide it is found that the conversion of the pearlite to hardenite considerably decreases its solubility (in both acids) as compared with all the varieties of pearlite. Little decisive difference is observed between the steels containing the laminated and diffused varieties of pearlite, whilst the resolution of the normal pearlite into the emulsified variety results in a decreased solubility below 0·2 per cent. to 0·3 per cent. carbon and a greatly increased solubility in the upper part of the range above 0·7 per cent. carbon.

Determination of Solution Pressures in Acid Solutions.

The solution pressures in 1 per cent. H_2SO_4 after twenty-four hours' immersion have also been determined, and these results (shown in fig. 3) again indicate the influence exerted by the carbon to be of two main types.

In the annealed, rolled, and normalised steels—taking E.M.F. in volts and carbon percentage as co-ordinates—two distinct maxima

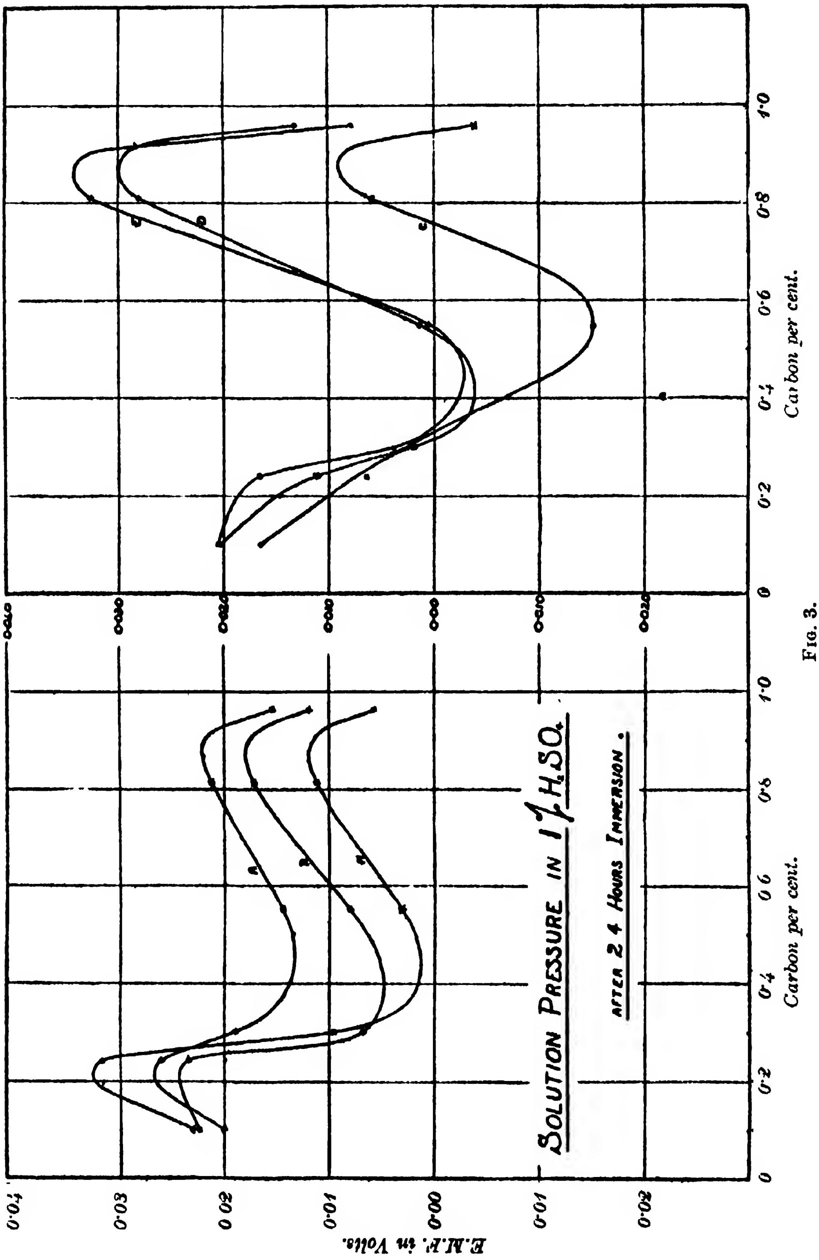

Solution Pressure in 1% H2SO4
After 24 Hours Immersion.
E.M.F. in Volts.
0·04
0·03
0·02
0·01
0·00
0·01
0·02
0·040
0·030
0·020
0·010
0·00
0·010
0·020
Carbon per cent.
0
0·2
0·4
0·6
0·8
1·0
Carbon per cent.
0
0·2
0·4
0·6
0·8
1·0
A
B
C
A
B
C

FIG. 3.

are observed at 0·22 per cent. carbon and saturation point respectively, whilst the values for E.M.F. reach a minimum at 0·45 per cent. carbon. The values given at the 0·22 per cent. carbon maximum are much higher than those at the saturation point.

In the case of the hardened and tempered steels, the values of E.M.F. fall directly from 0·10 per cent. carbon to a minimum at approximately 0·4 per cent to 0·5 per cent. carbon, after which a rapid rise to a maximum at saturation point takes place, followed by a sharp fall to 0·96 per cent. carbon.

The relations between the values given by the various types of treatment are analogous to those noted in the case of the solubilities. The hardened steels are consistently electronegative to the other steels. The tempered steels are electronegative to the annealed, normalised, and rolled steels below 0·50 per cent. carbon, whilst the relative electrochemical positions are reversed in the range from 0·7 per cent. up to 0·95 per cent. carbon. Very little difference is produced in this direction by difference in the tempering temperature, as is shown by the close agreement of the results given by the two tempered series. The divergence between the annealed, normalised, and rolled steels becomes quite distinct above 0·3 per cent. carbon when the annealed steels become the most electropositive, whilst the normalised steels take up the most electronegative position in this group of steels when immersed in 1 per cent. H_2SO_4. Below 0·30 per cent. C. the relative electrochemical positions become confused and inconclusive. There appears little doubt that the results obtained in this section of the research indicate substantially the relative electro-chemical positions which would be taken up by the various steels on immersion under galvanic conditions in 1 per cent. H_2SO_4 solution or in acid mineral waters of a similar type.

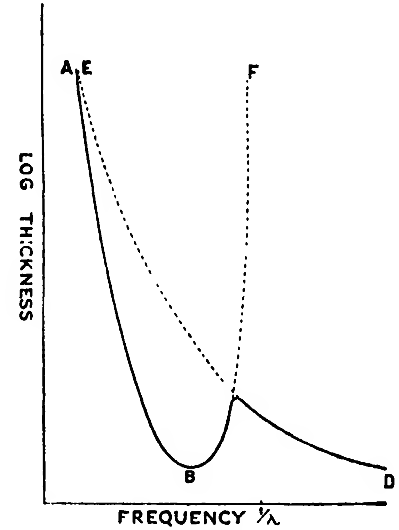
It will be observed that the resistance offered by carbon steels to disintegration when immersed in solutions varies considerably according as to whether the solution is of the sea-water type or is acid in character, and also as to whether the conditions of immersion are simple or galvanic in nature. It is impossible, therefore, to specify any particular composition or treatment offering the best resistance to attack under all conditions, and each case must be considered according to the circumstances involved.

Dynamic Isomerism.—Report of the Committee, consisting of Professor H. E. ARMSTRONG (*Chairman*), Dr. T. M. LOWRY (*Secretary*), Professor SYDNEY YOUNG, Dr. C. H. DESCH, Dr. J. J. DOBBIE, Dr. M. O. FORSTER, *and* DR. A. LAPWORTH. (*Drawn up by the Secretary.*)

General and Specific Absorption.

NEARLY all carbon compounds absorb light to a considerable extent in the far ultra-violet. If the thickness of the column of liquid be diminished the limit of transmission extends, as a rule, progressively

in the direction of the visible region; on plotting the thickness against the limit of transmission ($^1/\lambda$) a curve D C E of general absorption is obtained in shape resembling roughly a portion of a parabola. In addition to this general absorptive power, many liquids have the property of absorbing specifically light of a particular wave-length; but this absorption (unlike the line-spectra of vapours) covers a considerable range of wave-lengths on either side of the maximum absorption; this range increases as the thickness of the liquid is increased, so that the curve A B F of 'specific' absorption is somewhat of the shape of a narrow parabola. As the curve of general absorption intersects the curve of specific absorption at different distances on the axis of 'thickness,' the arms of the parabola are unequal in length, the complete curve being generally of the form A B C D. The point B is the 'head' of the band; the thickness at which it occurs under given experimental conditions is a measure of the 'penetration' of the band, whilst the range of thickness from B to C is a measure of its 'persistence.' Both quantities are conveniently measured in terms of 'log. thickness in millimetres of millinormal solution,' *e.g.*, if B=10 mm. and C=100 mm. then



log penetration $=1{\cdot}0$
log persistence $=2{\cdot}0-1{\cdot}0=1{\cdot}0$.

It will be noticed that the depth of penetration of the band is the best measure of the intensity of the local absorption, whilst the persistence, which depends on the relationship of the local to the general absorption, is likely to be greater when the head of the band occurs at a low than at a high frequency.

In classifying absorption-spectra it has been customary to draw

a sharp distinction between those substances which produce only a 'general' absorption of light and those which give rise to definite absorption 'bands.' It has even been suggested that this property might be used to classify carbon compounds into two groups, one group characterised by a 'fixed' structure and giving rise to general absorption, the other group including 'labile' compounds undergoing isomeric change readily and giving rise to banded spectra. The impracticability of this demarcation was shown in the report presented at Winnipeg in 1909, in which an account was given of several labile compounds which gave 'continuous' absorption curves, whilst certain compounds of fixed structure were shown to produce 'banded' absorption.

In the report presented at Sheffield in 1910 the origin of banded spectra was considered, special attention being directed to those alterations of molecular structure which have the effect of increasing or diminishing the intensity of the local absorption. It was found that by reducing the residual affinity of the absorbing centres an absorption band could be driven back almost to the extreme limit of oscillation-frequency at which it can be photographed by ordinary methods, and that any further weakening of the absorbing centres had the effect of converting the banded into a general absorption. The view was therefore adopted that a curve of general absorption might be produced by a band situated in such a position as to be inaccessible to ordinary methods of observation, say at $^1/\lambda$ 4200 or beyond.

During the past year attention has been directed to the study of general absorption and attempts have been made to determine the approximate positions of the inaccessible bands to which this type of absorption curve appears to be due. The method adopted depends on the well-known fact that most of the optical constants of a substance increase with great rapidity when an absorption-band is approached and appear to tend towards an infinite value in the case of a sharply defined absorption-line. In applying this method to carbon compounds the magnetic rotatory dispersion has been found to be a very convenient property to discuss, and measurements of this kind have been used to calculate the limit of transmission for a large number of substances—in other words, the position of the heads of the inaccessible bands by which the general absorption is produced. Typical values are as follows:—

	λ	$^1/\lambda$
Methyl and ethyl alcohols	**1300**	**7500**
Propyl alcohol, normal esters	**1350**	**7400**
Fatty acids, higher ketones, glycol, glycerol .	**1380**	**7200**
Higher alcohols (*pr.* and *sec.*)	**1400**	**7100**
Water, acetone, *ter.* alcohols	**1500**	**6700**
Allyl alcohol	**1700**	**5800**
Phenyl ethyl carbinol	**2000**	**4900**
Carbon disulphide	**2200**	**4350**

The chief points to be noted are:—

(1) That the optical properties of the majority of saturated carbon-compounds are determined mainly by an absorption in the far ultra-violet at wave-length 1300 to 1400; this appears to represent the extreme limit of transmission in the case of all compounds containing carbon, hydrogen, and oxygen.

(2) The shallow absorption bands which appear in the near ultra-violet region at wave-lengths from 3000 to 4200 in the case of substances such as acetone are almost without influence on the optical properties of these substances in the visible region.

(3) The dominant absorption may, however, be brought nearer to the visible region by introducing an ethenoid linkage, as in allyl alcohol, or a benzenoid nucleus as in phenyl ethyl carbinol; but in none of the simple compounds of which the magnetic rotatory dispersion has been determined does the dominant absorption fall within the region usually photographed in the study of absorption spectra.

The Transformation of Aromatic Nitroamines and Allied Substances, and its Relation to Substitution in Benzene Derivatives.—Report of the Committee, consisting of Professor F. S. Kipping (*Chairman*), Professor K. J. P. Orton (*Secretary*), Dr. S. Ruhemann, Dr. A. Lapworth, *and* Dr. J. T. Hewitt.

Transformations of Chloro- and Bromo-amines into Halogenanilides.

In last year's Report the following conclusions were reached:—

1. The chlorination and bromination of anilides is a direct process, and does not take place by way of the chloro- or bromo-amines. These substances are by-products.

2. The conversion of a chloroamine into the isomeric chloroanilide can only take place in the presence of hydrogen chloride. This acid and the chloroamine react reversibly:—

$$Ar{\cdot}NCl{\cdot}Ac + HCl \rightleftarrows Ar{\cdot}NH{\cdot}Ac + Cl_2.$$

The anilide and chlorine can then react directly, forming chloroanilide.

Hydrogen bromide (and hydrogen iodide) react similarly, for example, in a suitable medium:—

$$Ar{\cdot}NCl{\cdot}Ac + HBr \rightleftarrows BrCl + Ar{\cdot}NH{\cdot}Ac.$$

Bromination of the anilide and not chlorination now ensues.

3. When chlorine reacts with an anilide, two very rapid changes occur side by side, (*a*) the formation of a chloroamine, $Ar{\cdot}NCl{\cdot}Ac$, and hydrogen chloride, N-chlorination; (*b*) the formation of a chloroanilide, $ClAr{\cdot}NH{\cdot}Ac$, and hydrogen chloride, C-chlorination.

4. The existence of a complex, $Ar{\cdot}NH{\cdot}AcCl_2$, as an intermediary in these reactions was discussed. Its relations are shown in the scheme:—

$$\begin{tikzcd}[row sep=small] & & Ar{\cdot}NCl{\cdot}Ac + HCl \arrow[dl, dashed] \\ Cl_2 + Ar{\cdot}NH{\cdot}Ac \arrow[r, shift left] & Ar{\cdot}NH{\cdot}AcCl_2 \arrow[l, shift left] \arrow[ur, dashed] \arrow[dr, dashed] & \\ & & ClAr{\cdot}NH{\cdot}Ac + HCl. \end{tikzcd}$$

Although its existence is not excluded by the results, it was shown that such a complex must have very different properties in the case of different anilides; as the composition of the medium is changed, the

concentration of the complex must vary greatly; the speed of the transformation of the complex into chloroanilides must depend not only on the constitution of the amide but also on the constitution of the medium.

To avoid such a number of arbitrary assumptions it seems at least simpler to regard chlorination as occurring directly and not by way of such a complex.

The Velocity of Chlorination of Anilides.[1] (*With* HAROLD KING, *M.Sc.*)

The speed of the chlorination of anilides is being investigated with the object of ascertaining the effect of the nature, the number, and the position of various substituents, and the effect of acyl groups on the reaction.

Owing to the simultaneous formation of chloroamines, $Ar\cdot NCl\cdot Ac$ and C-chloro-derivatives, $ClAr\cdot NH\cdot Ac$, in dilute acetic acids, it is obviously simplest to measure the speed of the formation of the latter, in glacial acetic acid, when the former does not occur.

In glacial acetic acid, the reaction of chlorine and anilide is of the second order. It appears to be quite simple in character; no disturbing side reactions are observed, and the values of the velocity coefficients are remarkably constant throughout the reaction.

As the change proceeds hydrogen chloride appears in the solution. Control experiments have shown that even when as much as 8-gram molecular proportions of the acid are added, the velocity of chlorination is not affected. This fact offers a marked contrast to bromine in the presence of hydrogen bromide. Addition of hydrogen bromide arrests the bromination of anilides owing to the formation of hydrogen perbromide, HBr_3 (compare Report 1910).

The following table gives the value of the velocity coefficient, k'', temperature 16°, concentrations in gram molecules per litre, and time in minutes:—

	k_{II}		k_{II}
Formanilide	4·95	Aceto-*o*-toluidide	9
Acetanilide	40	Aceto-*p*-toluidide	77
Propionanilide	72	Benzo-*o*-toluidide	5·7
Butyranilide	64·5	Benzo-*p*-toluidide	70
*iso*Valeranilide	57	Aceto-*m*-xylidide	9
Stearanilide	61	Aceto-ψ-cumidide	630
Oxanilide	2	Aceto-α-naphthalide	550
Benzanilide	42	Aceto-β-naphthalide	∞
Aceto-*o*-anisidide	60	Formo-α-naphthalide	365
Aceto-*p*-anisidide	57	*o*-Chloroacetanalide	0·073
Aceto-*o*-phenetidide	90	*p*-Chloroacetanilide	0·21
Aceto-*p*-phenetidide	85	*p*-Chlorobenzanilide	0·16

Relation between the Nature of the Acyl Groups, and the Proportion of Ortho- and Para-Chloro-derivatives formed in chlorinating Acylanilides.[2] (*With* HAROLD KING.)

We have extended the experiments begun by Mr. W. J. Jones[3] on the estimation of the proportion of *o*- and *p*-chloro-derivatives which are

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[1] *Trans. Chem. Soc.*, 1911, **99**, 1369.

[2] *Ibid.*, 1911, **99**, 1377.

[3] *Ibid.*, 1909, **95**, 1056.

formed in the chlorination of acylanilides. The results so far obtained are shown in the table. The acyl group is found to have a very powerful influence. Other circumstances, media, temperature, and concentration, have little effect on the proportion, but the production of a dichloro-derivative is more pronounced in other media than dilute acetic acid.

The numbers represent the percentage of the anilide chlorinated, found in the product in one or other form.

Anilide	*p*-Chloro-anilide	*o*-Chloro-anilide	Ratio *o*-Chloroanilide *p*-Chloroanilide	2 4-Dichloro-anilide	Unchanged anilide
Acetanilide .	51	44	0·89/1	1·2	1·2
Propionanilide .	64	26	0·4/1	3·2	3·2
Stearanilide .	69·5	20·8	0·3/1	2·2	2·2
Benzanilide .	65·5	11·2	0·17/1	11·1	9·2
Formanilide .	62	3·0	0·048/1		--

Obviously the chlorination of acetanilide is the best method of preparing *o*-chloroaniline.

An Application of the Reaction between Chloroamines and Hydrogen Chloride as a method of Chlorinating Anilines and Phenols.[4] (*With* HAROLD KING.)

The fact that chloroamines and hydrogen chloride react quantitatively in glacial acetic acid producing anilide and chlorine, gives a very effective method of chlorinating such anilides and phenols as are particularly susceptible of oxidation, or by the usual methods yield di- or poly-chloro-derivatives.

Molecular proportions of the substance to be chlorinated and a chloroamine, for example, that derived from 2 : 4-dichloroacetanilide or *p*-nitroacetanilide, are mixed in glacial acetic acid solution, and some small proportion of hydrogen chloride, one-hundredth to one-twentieth gram molecular proportion, added. From the reaction between the chloroamine and the hydrogen chloride, chlorine is formed in amount molecularly equivalent to the hydrogen chloride used. The chlorine in its turn attacks the substance to be chlorinated, forming at the same time an equivalent of hydrogen chloride. Chlorine is again regenerated, and hence is thus maintained at a constant low concentration, fixed by the amount of hydrogen chloride originally introduced, through the greater part of the reaction.

In this way 5-chloro-*m*-xylidine, 6-chloro-ψ-cumidine, 5-chloro-*o*-anisidine, 5-chloro-*p*-anisidine, 5-chloro-*o*-phenetidine and 5-chloro-*m*-xylenol have been for the first time prepared. Further, Mr. King has been able to chlorinate α-naphthol directly without any oxidation. Owing to the fact, however, that the speeds of interaction of α-naphthol and 4-chloro-α-naphthol and chlorine are of similar magnitude, much

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[4] *Trans. Chem. Soc.*, 1911, **99**, 1185.

2 : 4-dichloro-α-naphthol is formed, and hence an equivalent quantity of α-naphthol remains unchanged. α-naphthol can be quantitatively converted into 2 : 4-dichloronaphthol by this method.

Formation of Nitroamines. (*With* Miss M. G. Edwards.)

There is no easier way of preparing certain nitroaminobenzenes than by treatment of the aniline in acetic acid solution with a mixture of acetic anhydride and nitric acid in the same solvent. With di-ortho-(negatively)-substituted anilines the yield of nitroamine is quantitative. With other anilines the acetyl derivative is formed simultaneously, owing to the more rapid interaction of acetic anhydride with anilines in which an ortho position is unoccupied, or not occupied by a negative group. The proportion of nitroamine to acetyl derivative can be to a certain extent regulated by variation of the concentrations of the acetic anhydride and nitric acid.

It appears to be generally thought that the formation of the nitroamine is due to the dehydration of the aniline nitrate. There is, however, much evidence that such is not the case.

1. It was shown by Smith and Orton[5] that all acids, except nitric acid, acted as powerful accelerators of acetylation of anilines by acetic anhydride. There is no formation of the anilide of the acid, of the type corresponding to the nitroamine.

2. Measurements have been made of the rate of the formation of nitroamines by this method. In one series of experiments the anhydride is added to a mixture of aniline and nitric acid in acetic acid; a relatively slow regular formation of nitroamine follows. In other series the anhydride and nitric acid are mixed in acetic acid and then added to the solution of the aniline; a very rapid formation of the nitroamine takes place, the speed, however, falling off after about half the reaction is over.

This result obviously suggests that a compound of acetic anhydride and the nitric acid is the nitrating agent. In the second series it can be formed and reach a high concentration before it is brought in contact with the aniline. This compound may be the compound prepared by Pictet,[6] $(CH_3{\cdot}CO_2)N_2(OH)_3$, or even acetyl nitrate.

3. A remarkable confirmation of this view is found in some experiments which have been recently carried out on the hydrolysis of acetic anhydride (with Miss M. Jones). The anhydride was dissolved in a large excess of acetic acid, which contains a small proportion of water, 0·12 to 0·2 per cent. The hydrolysis of acetic anhydride in this medium is extremely slow at the ordinary temperature. In the presence of small proportions ($\frac{1}{8}$ to $\frac{1}{4}$ gram molecular proportion) of all mineral acids, with the exception of nitric acid, an extremely rapid hydrolysis occurs. With nitric acid there is no acceleration, but even a retardation of the hydrolysis. In dilute (80 per cent.) acetic acid there is no difference between nitric acid and other acids.

There seems little doubt then that nitric acid and acetic anhydride, even when largely diluted with acetic acid, very rapidly react or

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[5] *Trans. Chem. Soc.*, 1908 and 1909.

[6] *Zentralblatt.*, 1903, ii, 1109.

combine. On the one hand this compound attacks anilines, forming nitroamines, and not acetyl derivatives, and on the other hand this compound does not react with water more rapidly than acetic anhydride itself.

The Committee desire to be reappointed for the coming year, and ask for a grant of 15*l*.

Electroanalysis.—Report of the Committee, consisting of Professor F. S. Kipping (*Chairman*), Dr. F. M. Perkin (*Secretary*), Dr. G. T. Beilby, Dr. T. M. Lowry, Professor W. J. Pope, *and* Dr. H. J. S. Sand. (*Drawn up by* Dr. H. J. S. Sand.)

Attention has been directed during the past year particularly to the application of the electrometric method to the titration of weak acids in such liquids as tan liquors. It was found that the potentiometer-box and auxiliary electrode constructed for the separation of metals by graded potential may be conveniently employed for this purpose in conjunction with a form of hydrogen electrode specially designed to combine ease of manipulation and rapidity of saturation. The question regarding the ' end-point ' of the titration has been examined. It is known that if the object of the titration be to determine the number of equivalents of acid present, then not only the nature of the acid or acids must be considered but also the concentration of the salts resulting from the titration. It has been pointed out, however, that in most practical cases it will be possible to fix end-points of special importance for the particular purpose in question. Frequently the liquid may be titrated until the hydrion-concentration of pure water is reached. This corresponds to a potential difference between the hydrogen-electrode and the normal calomel electrode recommended for these titrations, of 0·69 volt.[1]

By Dr. F. Mollwo Perkin.—It has been found possible by Hildebrand[2] and E. F. Smith and his co-workers to electrolyse the alkali metals with a mercury cathode and to analyse both the anion and cation. For this purpose a double cell is employed, the inner and outer portion being sealed by means of mercury. The alkali salt to be analysed, say potassium sulphate, is placed in solution in the central cell where an anode of platinum gauze is rapidly rotated. The outer cell contains water with a small quantity of sodium chloride solution to make it conductive. On electrolysing, the SO_4 anions are discharged at the anode and a solution of sulphuric acid obtained. The K cations are discharged on the mercury which is made the cathode. Owing to the rotation of the anode the amalgam, which is specifically lighter than the pure mercury, is swept into the outer compartment

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[1] See Part I. *Journ. Soc. Chem. Ind.* (in conjunction with D. J. Law), 1911, 30, 3; reprinted in full *Journ. Amer. Leatherchemists Assn.*, 1911, 114; and *Ledermarkts Kollegium*, 1911, p. 150, Part II. (in conjunction with J. T. Wood and D. J. Law), *Journ. Soc. Chem. Ind.*, July 31, 1911.

[2] *Chem. Zentralblat.*, 1907, ii., 8.

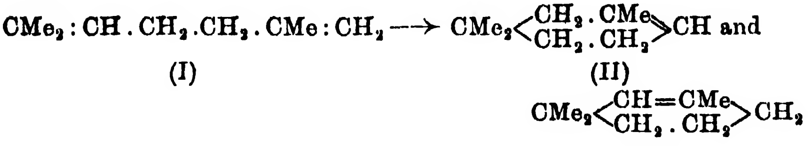
where it is decomposed by means of an auxiliary nickel cathode placed above the mercury in the solution. When the electrolysis is complete the SO_4 in the inner cell is titrated by means of standard alkali and the K in the outer cell by means of standard acid.

There are disadvantages in the apparatus of Hildebrand, the outer cell of which is a glass crystallising basin, the inner consisting of a beaker with the bottom cut off. The inner cell is kept in a central position by having corks wedged at the sides. F. M. Perkin has now had a vessel made of fused quartz. The centre cell is kept concentric by having quartz rods fused to it and to the inside wall of the outer basin. Being of quartz, the vessel can for cleaning purposes be heated to redness, is absolutely unattacked by alkali, and there are no corks which, if they get accidentally splashed, absorb some of the alkali and vitiate the results.

Experiments on the analysis of the anions and cations are being carried out with this apparatus, and the results so far have been encouraging.

The Study of Hydro-aromatic Substances.—Report of the Committee, consisting of DR. E. DIVERS *(Chairman)*, PROFESSOR A. W. CROSSLEY *(Secretary)*, PROFESSOR W. H. PERKIN, DR. M. O. FORSTER, *and* DR. H. R. LE SUEUR.

Synthesis of cyclogeraniolene (1 : 1 : 3-trimethylcyclohexene).[1]—Some years ago Tiemann and Semmler[2] prepared from the aldehyde citral (geraniol) an open-chain hydrocarbon, C_9H_{16}, named by them geraniolene. The constitution of this substance (I) follows from that of citral, which was established by Barbier and Bouveault in 1896.[3] When geraniolene is shaken with a 60 per cent. solution of sulphuric acid, an isomeric change takes place, the open-chain hydrocarbon being converted into a mixture of two cyclic hydrocarbons α and β cyclogeraniolene (II and III), in which mixture the α variety is present in larger quantity.



$$CMe_2:CH.CH_2.CH_2.CMe:CH_2 \longrightarrow CMe_2{<}{\substack{CH_2.CMe\\CH_2.CH_2}}{>}CH \text{ and }$$

(I) (II)

$$CMe_2{<}{\substack{CH{=}CMe\\CH_2.CH_2}}{>}CH_2$$

(III)

Constitutional formulæ were assigned to these hydrocarbons by Tiemann,[4] arrived at from a study of their oxidation with potassium permanganate, and these formulæ are proved to be correct by the following synthesis.

1:1-Dimethylcyclohexanone (IV) was treated with an ethereal

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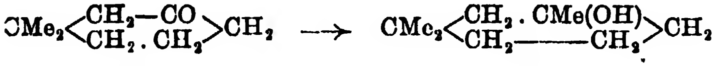
[1] Crossley and Gilling, *J.C.S.*, 1910, 97, 2218.

[2] *Ber.*, 1893, 26, 2708.

[3] *Compt. rend.*, 122, 393.

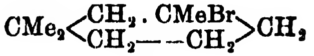
[4] *Ber.*, 1898, 31, 816, 881; 1900, 33, 3711.

solution of magnesium methyl iodide and the product decomposed with water, when trimethylcyclohexanol (V) was obtained as a well-defined, crystalline substance, melting at 72°·5.



$$\mathrm{CMe_2}{<}\begin{matrix}\mathrm{CH_2{-}CO}\\ \mathrm{CH_2\,.\,CH_2}\end{matrix}{>}\mathrm{CH_2} \longrightarrow \mathrm{CMe_2}{<}\begin{matrix}\mathrm{CH_2\,.\,CMe(OH)}\\ \mathrm{CH_2{-\!-\!-}CH_2}\end{matrix}{>}\mathrm{CH_2}$$

(IV) (V)

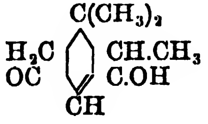


$$\mathrm{CMe_2}{<}\begin{matrix}\mathrm{CH_2\,.\,CMeBr}\\ \mathrm{CH_2{-\!-}CH_2}\end{matrix}{>}\mathrm{CH_2}$$

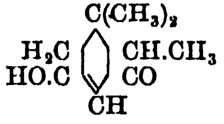
(VI)

Fuming hydrobromic acid converts the alcohol into 3-bromo-1:1:3-trimethylcyclohexane (VI), which, when treated with alcoholic potassium hydroxide, loses the elements of hydrogen bromide in two ways, giving rise to the same mixture of hydrocarbons as described by Tiemann. The identity was established by preparing the crystalline nitrosate, and from it the oxime described by Wallach[5]; further by oxidising the hydrocarbons with potassium permanganate, when the products isolated were *as*-dimethylsuccinic acid, *iso*geronic and geronic acids.

1:1:2-*Trimethylcyclohexan-3-one.*[6] Brief reference was made in the last Report[7] to the method adopted for the preparation of this ketone, the object of its isolation being to compare its properties with those of camphor on account of the marked similarity of the various groupings in the molecules of these two ketones. Further, it was thought that a more extended inquiry into the chemical behaviour of trimethyldihydroresorcin than has hitherto been carried out was desirable because, unlike dimethyldihydroresorcin (VII), its molecule is not symmetrical, and consequently several new points of interest are raised. This latter problem has proved to be more complicated than was anticipated, but there can be no doubt that trimethyldihydroresorcin is a tautomeric substance, exhibiting the two forms represented by formulæ VII and VIII



(VII)



(VIII)

the particular form manifested depending on the nature of the reagents with which the dihydroresorcin is brought in contact. As a result, in the series of reactions which give rise to 1 : 1 : 2-trimethylcyclohexan-3-one, both 1 : 1 : 2-trimethylcyclohexan-3-ol and 1 : 1 : 2-trimethylcyclohexan-5-ol are formed, both of which alcohols are capable of existing in *cis* and *trans* modifications, but so far only the *trans* form

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[5] *Annalen*, 1902, **324**, 97.
[6] Crossley and Renouf, *J.C.S.*, 1911, **99**.
[7] *Brit. Assoc. Report*, Sheffield, 1910, p. 82.

of 1 : 1 : 2-trimethylcyclohexan-3-ol has been isolated. These alcohols give rise to the corresponding ketones on oxidation, but here again only 1 : 1 : 2-trimethylcyclohexan-3-one has been isolated in a pure condition. Further experiments are now in progress.

Investigation of the Igneous and Associated Rocks of the Glensaul and Lough Nafooey Areas, Cos. Mayo and Galway.—Report of the Committee, consisting of Professor W. W. Watts *(Chairman)*, Professor S. H. Reynolds *(Secretary)*, Mr. H. B. Maufe, *and* Mr. C. I. Gardiner.

Mr. C. I. Gardiner and the Secretary visited the district in April and finished mapping the Kilbride peninsula. The general structure of this area was given in the Committee's report for 1910 (Sheffield), and except that a new exposure of Arenig sedimentary rocks has been found, the present year's work, though adding much to the detailed knowledge, has not led to the discovery of any facts which it is necessary to mention in the present report. It is hoped that a paper on the Kilbride peninsula will be read before the Geological Society during the coming session.

Erratic Blocks of the British Isles.—Report of the Committee, consisting of Mr. R. H. Tiddeman *(Chairman)*, Dr. A. R. Dwerryhouse *(Secretary)*, Dr. T. G. Bonney, Mr. F. M. Burton, Mr. F. W. Harmer, Rev. S. N. Harrison, Dr. J. Horne, Mr. W. Lower Carter, Professor W. J. Sollas, *and* Messrs. Wm. Hill, J. W. Stather, *and* J. H. Milton.

Reports have been received from the Belfast Naturalists' Field Club, the Hull Geological Society, the University of Durham Philosophical Society, and the Rev. A. Irving, D.Sc.

During a recent visit to the North of Ireland in company with the Secretary, Mr. B. N. Peach, F.R.S., was able to identify certain erratics found at Cushendall, co. Antrim, as derived from the Island of Arran. These included a Quartz Porphyry from Drum-a-Doon and granites probably derived from the Goat Fell area. It is hoped to deal more fully with these in the next report.

IRELAND.

Reported by the Committee of the Geological Section of the Belfast Naturalists' Field Club.

Co. Down.

Ballywalter.—Low bank of unstratified brown boulder clay, at sea-level, on coast one mile south of Ballywalter. Subjacent rock, Silurian grit. Out of 96 boulders noted, the following were erratics:

3 Ailsa Craig Riebeckite-eurite, 7 quartz, 2 flint, 1 chalk, 3 basalt, 1 red sandstone, 2 quartzite, 1 bole, 1 aphanite, 10 camptonite, 8 granite (Donegal type), 7 granite (Newtownards), 2 weathered sandstone, 1 grit (Ballygowan). The prevailing directions of the parent rock were north and north-west.

Magheralin.—Chalk quarry one-third of a mile north-east of Magheralin village. Unstratified red boulder-clay, about 150 feet above sea-level. Subjacent rock, chalk. Out of 131 boulders counted, the following erratics were noted: 34 basalt, 6 dolerite, 1 clay ironstone, 3 grit, 6 granite (similar to that of Barnesmore, co. Donegal), 1 granite (North Tyrone?), 9 mica schist, 1 eurite (Tornamoney), 11 quartzite, 4 pebbles Old Red conglomerate (Cushendun), 5 quartz, 1 porphyry (Cushendall), 2 diorite, 12 crushed diorite, 7 hornblende rock, 1 elvan, 1 Lower Carboniferous sandstone, 1 crushed felsite, 7 gabbro, 2 Lower Carboniferous conglomerate, 2 eurite (North Tyrone). Foraminifera found in the boulder clay.

Co. Antrim.

Kilcoan, Islandmagee.—Chalk quarry. Red unstratified boulder-clay. Few erratics; basalt largely preponderated, but 2 lias, 1 eurite, and 1 dolerite were also noted. At one end of the quarry, where the boulder-clay had been cleared off the top of the chalk, a fine striated surface was exposed Two sets of striæ were observed, running S. 5° W. and E. and W. respectively. So far as could be made out from the surface, the striæ from the west were subsequent and superimposed on those made by the ice moving from the north.

ENGLAND.

Hull Geological Society.

The members of the local Boulder Committee have done a fair amount of field work during the past year, but have nothing strikingly new to record.

Filey.—On the beach at Filey, a few yards north of Hunmanby Gap, a boulder of Bunter sandstone, 30 yards long, was noted, embedded in the glacial clays which form the beach in this locality. Mr. R. M. Robson reports a boulder of garnetiferous schist, between one and two tons in weight, at an elevation of 142 feet, three-quarters of a mile west of Filey.

Holderness.—In June Dr. U. Milthers, of the Danish Geological Survey, visited this country and spent several days on the East coast of Yorkshire examining the boulders. He was much impressed by the great display of Scandinavian boulders in South Holderness, chiefly from the Christiania district. One result of his visit will probably be the identification of some further Scandinavian rocks in East Yorks.

South Ferriby, Lincs.—Mr. T. Sheppard, F.G.S., records an exposure of the clays beneath the Red Chalk on the south Humber shore at South Ferriby. In these are embedded a number of large cake-shaped nodules, all of which are glacially striated on their upper surfaces, the striæ being from east to west, parallel with the old course of the Humber estuary. Close by, an exposure in the solid lower chalk

has recently occurred as a result of the covering deposits having been removed by the changes in the course of the Humber waters. This exposure reveals the pre-glacial bed of the Humber estuary, and it is interesting to observe that this also is striated in the same direction as the striæ on the cement-nodules already referred to.

Reported by the Northumberland and Durham Boulders Committee of the University of Durham Philosophical Society.

1. *Collected by* S. R. Haselhurst.—Percy Square to Spanish Battery, Tynemouth: Basalt, amygdaloidal with large crystals of anorthite; volcanic series of Borrowdale; red sandstone; syenite; porphyrite (St. Abbs Head); micaceous sandstone.

2. *Collected by* E. Merrick.—

(*a*) Cowpen Brick Works (late Standard Brick Works): Red fossiliferous Carboniferous limestone; syenite; andesite; porphyrite; three boulders of chalk.

(*b*) Sand Pit, South View, Ryton: Red granite; volcanic series of Borrowdale; ferruginous grit; Threlkeld granite.

(*c*) Brick's, Ltd., Forest Hall: Red porphyrite.

3. *Collected by* Dr. Woolacott and E. Merrick.—From foundations of new buildings for Art Department, Armstrong College: Carboniferous limestone; whin sill; volcanic series of Borrowdale; rhyolite 1 cubic foot; grey granite (Dalbeattie); sandstone.

4. *Collected by* Dr. Woolacott and G. T. Mackay.—A boulder of decomposed Laurvik syenite or similar rock from Christiania Fiord was observed on the coast about a mile north of Castle Eden.

5. *Collected by* A. Ball.—A piece of Laurvik syenite from Christiania was collected from the foundations of bridge across Castle Eden Dene.

(Note.—The two latter boulders, probably of Scandinavian origin, are of great interest as being the most northerly recorded occurrence of Scandinavian rocks in the English drift.)

6. *Collected by* Dr. Smythe.—(*a*) Pebble bed, Horsebridge Head, near Newbiggin. Result of many years' collecting.

Sedimentary.—Sandstone, commonest constituent, often containing plant remains (*Lepidodendron, Calamites*); Magnesian limestone abundant (one specimen with *Fenestrella retiformis*); Carboniferous limestone, not common, fossils often occur (*Productus, Lithostrotion*); Greywacke, not common; chalk flints (6); chalk (1); cherts and jaspers (22).

Igneous and metamorphic.—Whinstone, fairly common, pebbles up to 1 foot; of 210 other rocks there were 30 granites, white, grey, red, up to 6 inches; 20 mica and hornblende schists up to 8 inches; 56 porphyrites (many certainly from Cheviots); 3 glassy porphyrites and 4 andesites (Cheviots); 15 quartz porphyries with white, pink, green, and red groundmass, up to 6 inches; 17 syenites; 3 mica porphyrites; 1 diorite; 61 weathered rocks, mostly porphyritic.

(*b*) Akenshaw Burn: Black chert, abundant; granite (grey and red) 10; syenite 3; diorite; porphyrite; amygdaloidal basalt.

(*c*) Whickhope Burn: Black chert, abundant; granite 4; quartz porphyry 2.

(*d*) Chirdon Burn: Granites 8; syenite; greywacke; basalt.

(*e*) Pundershaw Burn: Granites 7; Carboniferous limestone crowded with spines of *Productus*; porphyrites 2; volcanic series of Borrowdale (?); quartz porphyry; syenite.

(*f*) Coalcoates, Wark's Burn: Red sandstone (Permian or Trias); granites 11; mica syenite 1; volcanic series of Borrowdale 1.

(*g*) Coal Cleugh, Middle Burn, Wark's Burn: Syenite (same rock found in Pundershaw and Sweethope drift); granites 7; quartz porphyries 3; syenite; porphyry; greywacke; diorite.

(*h*) Deposit foot of Lyne Burn: Flints 5; chalk; garnetiferous mica schist (Pitlochrie?) 4; Magnesian limestone abundant, fossiliferous; mica schist 2; basalts (abundant); quartz porphyry; syenite; Cheviot porphyrites 16; trachyte; chert 2; several greywackes; limestone and sandstone. (NOTE.—Whickhope and Akenshaw drift dam the Wansbeck to Mitford. Volcanic series of Borrowdale occur south of Wark's Burn (present in Liddle Hall Kaims).)

Striations have been observed on the rock surface by Dr. Smythe at the following places: Barrow Hill (Alwinton), 800 feet E.; Harbottle Hill (Alwinton), 950 feet E. by N.; Amerside Law (Chillingham), 1,000 feet S. by W.; Bellshill, S. 20° E. All these striations were on sandstone.

Reported by Rev. A. IRVING, D.Sc.—From Hockerill Vicarage, Bishop's Stortford (235 feet): Lydite; dolerite 2; red granite, jasper 2; quartzite (several); red chalk.

From Parsonage Lane, Bishop's Stortford (220 to 230 feet): Trap; dolerite; red granite; quartzite; Carboniferous limestone (striated); red chalk.

From Maple Avenue, Bishop's Stortford (290 feet): Dolerite; jasper; basalt; phyllite; millstone grit 3; shelly limestone; limestone; red chalk; white chalk; hæmatite.

From Hockerill Churchyard (240 feet): Ash; Carboniferous limestone; white chalk.

From The Grange, Bishop's Stortford (215 feet): Limestone.

From Town Cemetery, Bishop's Stortford (260 feet): Pebbly sarsen.

From Start Hill (265 feet): Rhyolite 2; quartzite; Carboniferous limestone; white chalk.

From Sawbridgeworth (*c.* 250 feet): Dolerite; jasper; Rothschiefer (?); shelly limestone 2; Northampton ironstone; red chalk; septaria.

From Braintree: Carboniferous limestone.

The Fossil Flora and Fauna of the Midland Coalfields.—Report of the Committee, consisting of Dr. L. MOYSEY (*Chairman*), Dr. B. HOBSON (*Secretary*), Mr. H. BOLTON, Dr. A. R. DWERRYHOUSE, *and* Dr. WHEELTON HIND, *appointed to investigate the Fossil Flora and Fauna of the Midland Coalfields.*

INVESTIGATION OF THE FOSSIL FLORA AND FAUNA OF THE MIDLAND COALFIELDS. By A. R. HORWOOD.

I HAVE collected personally in Warwickshire, and obtained assistance in North Derbyshire, in addition to that rendered by men on the spot. I wish to thank those who have collected for me in general, in addition to those specially mentioned hereafter. As this is a general report, minute details are not given. I also desire to thank Dr. Wheelton Hind and Dr. A. Smith Woodward for identifying the mollusca and fish respectively. I have examined the other fossils here recorded.

Warwickshire.

This small coalfield has not hitherto been examined palæontologically, and the following results are therefore of special interest. As far as possible every exposure or pit has been examined, and although this report only covers three months' actual work, much has been done since then which does not come into this report, which is therefore only a partial record. The following fossils have all been collected by me. The chief coal-seams are, in descending order: Four Feet, Two Yard, Ryder, Bare, Ell, Slate, Seven Feet, Double or Deep, Bench. The Red Rocks have also received attention.

As a whole the flora and fauna of this tract resemble that of the Leicestershire and South Derbyshire coalfield; and, like it, the state of the fossils is very unsatisfactory, both plants and animal remains being also rare.

Abbreviations for the localities visited are as follows:—

Ch. = Charity Pit, Bedworth.
Ex. = Exhall Colliery.
Gr. = Griff No. 4 Pit, Nuneaton.
Gr.Cl. = Griff Clara Pit, Nuneaton.
Ha. = Haunchwood Old Pit, Stockingford.
Ne. = Newdigate Colliery, near Bedworth.
Nu. = Nuneaton Colliery, Stockingford.
St. = Stockingford Old Colliery.
Tu. = Tunnel Pit, Stockingford.
Wy. = Wykon Colliery.

Genera and Species	*Bench Seam	*Seven Foot Seam	Slate Seam	Ryder Seam	Two Yard Seam	*Four Foot Seam
PLANTÆ.						
FILICALES ET PTERIDOSPERMÆ.						
Sphenopteris, spp. . . .	—	—	—	—	Gr. Cl.	—
Urnatopteris tenella (Brongt.) .	—	—	—	—	Gr. Cl.	—
Crossotheca schatz larensis (Stur).	—	—	—	—	Gr. Cl.	—
" sp. . . .	—	—	Gr.	—	—	—
Mariopteris muricata (Schl.) .	—	—	Ex. Gr. Wy.	—	Nu.	—

* These horizons are now being examined.

Genera and Species	*Bench Seam	*Seven Foot Seam	Slate Seam	Ryder Seam	Two Yard Seam	*Four Foot Seam
FILICALES ET PTERIDOSPERMÆ—*cont.*						
Alethopteris lonchitica (Schl.)	—	—	Ex.	—	No.	—
,, *decurrens* (Artis)	—	—	Ex.	—	—	—
Neuropteris heterophylla (Brongt.)	—	—	Ex. Gr. St. Wy.	St.	Gr. Cl. Ha. Nu.	—
,, *tenuifolia* (Schloth.)	—	—	Ex. Gr. Nu.	St.	Gr.	—
,, *obliqua* (Brongt.)	—	—	Wy.	St.	Gr. Cl. Nu.	— —
,, *gigantea* (Sternb.)	—	—	Ex. Gr. Wy.	—	No.	—
,, *scheuchzeri* (Hoffm.)	—	—	Gr.	—	Nu.	—
EQUISETALES.						
Calamites schutzei (Stur.)	—	—	Gr. Wy.	—	Ha. No. Nu.	—
,, *undulatus* (Sternb.)	—	—	Wy.	—	Nu.	—
,, *ramosus* (Artis)	—	—	St. Wy.	—	Ha. Nu. St.	—
,, *suckovii* (Brongt.)	—	—	Gr. St. Wy.	—	Ha.	—
,, *cistii* (Brongt.)	—	—	Gr. St.	—	Nu. Tu.	—
Calamocladus equisetiformis (Schloth.)	—	—	—	—	Ha.	—
,, *charæformis* (Sternb.)	—	—	Nu.	—	—	—
,, *lycopodioides* (Zeiller)	—	—	—	—	Ha. St.	—
Calamostachys, sp.	—	—	—	St.	—	—
Annularia radiata (Brongt.)	—	—	Gr. Gr. Cl. St.	—	Ha. Nu.	—
SPHENOPHYLLALES.						
Sphenophyllum cuneifolium (Sternb.)	—	St.	Gr.	—	Gr. Cl. Ha. No. Nu.	—
,, var. *saxifragæfolium* (Sternb.)	—	—	Gr.	—	Gr. Cl. Ha. Nu. St.	—
Sphenophyllum trichomatosum (Stur)	—	—	—	—	Gr. Cl. Ha. St.	—
LYCOPODIALES.						
Lepidodendron ophiurus (Brongt.)	—	—	St. Wy.	—	St.	—
,, *aculeatum* (Sternb.)	—	—	Gr. St.	—	Gr. Cl.	—
,, *obovatum* (Sternb.)	—	—	St.	—	Gr. Cl. Ha. Nu.	—

* These horizons are now being examined.

Genera and Species	*Bench Seam	*Seven Foot Seam	Slate Seam	Ryder Seam	Two Yard Seam	*Four Foot Seam
Lycopodiales—*cont.*						
Lepidostrobus variabilis (L. & H.)	—	—	St.	—	Gr. Cl. Ha. Nu.	—
,, sp.	—	—	Wy.	—	—	—
Lepidophyllum majus (Brongt.)	—	—	—	—	Tu.	—
,, *triangulare* (Zeiller)	—	—	Gr.	—	—	—
Lepidophloios acerosus (L. & H.)	—	—	—	—	Gr. Cl. Nu.	—
,, sp.	—	—	Wy.	—	—	—
Cyperites bicarinata (L. & H.)	—	—	—	—	Nu.	—
Stigmaria ficoides (Sternb.) .	—	—	Ch. Gr. Gr. Cl. St. Wy.	—	Ha. Ne. Nu.	—
Stigmariopsis anglica (Kidst.) .	—	—	Ex.	—	Gr. Cl.	—
,, sp.	—	—	—	—	Nu.	—
Cordaitales.						
Cordaites principalis (Germar) .	—	—	Wy.	—	—	—
Cordaianthus pitcairniæ (L.&H.)	—	—	St.	—	—	—
,, *anomalus* (Morris).	—	—	—	—	Nu.	—
Carpolithes ovoideus (Gopp.) .	—	—	Gr. St.	—	Ha.	—
,, sp.	—	—	—	—	Nu.	—
Incertæ Sedis.						
Pinnularia capillacea (L. & H.)	—	—	Ex. Gr. Wy.	—	Gr. Cl. Ne. Nu. St.	—
ANIMALIA.						
Annelida.						
Spirorbis pusillus (Mart.) . .	—	—	—	—	Ha. Tu.	—
Worm-castings	—	—	—	—	Ne. St. Tu.	—
Crustacea.						
Entomostraca	—	—	—	—	Ch.	—
Lamellibranchiata.						
Carbonicola nucularis (Hind) .	—	—	—	—	No.	—
,, *turgida* (Brown) .	—	—	Nu. St.	—	Ha. Ne. Tu.	—
,, *aquilina* (Sow.) .	—	St.	Gr. Cl. St.	—	Ch. Ha. Ne. Nu. Tu.	—
,, *similis* (Brown) .	—	—	St.	—	—	—
Naiadites modiolaris (Sow.) .	—	—	—	—	Ch. Nu. St.	—
,, *triangularis* (Sow.) .	—	—	—	—	Ch.	—
,, *carinata* (Sow.) .	—	—	—	—	Tu.	—
,, sp.	—	—	—	—	Ha.	
Pisces.						—
Cœlacanthus elegans (Newb.) .	—	—	—	—	Nu.	—

* These horizons are now being examined.

North Derbyshire and Notts.

North Derby and Notts are integral parts of one great coal-tract, continuous into Yorkshire, but for geographical purposes it is as well to refer to the following distribution of fossils as confined to the Northern part of North Derbyshire from which hitherto few collections had been made. I am indebted to Mr. W. Hemingway, who has been the means of adding so many rich treasures to our Carboniferous flora, for the whole of the collections here recorded, and for giving me the benefit of his wide field knowledge of Carboniferous plants.

In the table the coal-seams are arranged in ascending order, the lowest seam on the left. Abbreviations for localities are as follows:—

Av. 9=Avenue No. 9 Colliery, Chesterfield.
Bo.=Bond's Main Colliery, Grassmoor.
Bu.=Bullbridge Brickyard.
Ca.=Calow Main Colliery, Chesterfield.
Cl. 2=Claycross No. 2 Colliery, Claycross.
Cl. 4=Claycross No. 4 Colliery, Claycross.
Gr. 1=Grassmoor No. 1 Colliery, Grassmoor.
Gr. 4=Grassmoor No. 4 Colliery, Grassmoor.
Gr. 5=Grassmoor No. 5 Colliery, Grassmoor.
He.=Heage Colliery, Heage.
Hi.=Highfield Colliery, Sheepbridge.
Hl.=Holmwood Colliery, Heath.
Hn.=Hornthorpe Colliery, Eckington.
Me.=Mareham Colliery, Eckington.
Mk.=Markham Colliery, Staveley.
Mi.=Mickley Colliery, Dronfield.
No.=Norwood Colliery, Killamarsh.
Or.=Orchard Colliery, Unstone.
Pr.=Pearson's Colliery, Newbold.
Ro.=Rectory Colliery, Heage.
Rn.=Renishaw Park Colliery, Eckington.
S. Wi.=South Wingfield Colliery, Oakenthorpe.
St. H.=Stubbley Hollow Colliery, Dronfield.
Tu.=Turnoak Colliery, Chesterfield.
Wa.=Wallsend Colliery, Newbold.
Wi.=Williamthorpe Colliery, Heath.

Genera and Species	Belper Lawn	Alton	Naughton	Kilburn	Mickley	Black Shale	Furnace	Hospital	Deep Hard	Deep Soft	Ell	Waterloo	Dunsil	Top Hard	Clowne
PLANTÆ															
FILICALES ET PTERIDOSPERMÆ															
Sphenopteris sternbergii (Ett.)	—	—	—	—	—	Cl2	—	—	—	—	—	—	—	—	—
„ *multifida* (L. & H.)	—	—	—	—	—	Av.9	—	—	—	—	—	—	—	—	—
Crossotheca schatzlarensis (Stur)	—	—	—	—	Mi.	—	—	—	—	—	—	—	—	—	—
Pecopteris miltoni (Artis)	—	—	—	—	—	Bo. Ca. Gr.4	—	—	—	—	—	—	—	—	—
Dactylotheca plumosa (Artis)	—	—	—	—	—	Av. 9 Bo. Re.	—	—	—	—	—	—	—	—	—
Mariopteris muricata (Schl.)	—	—	—	S. Wi.	—	Av. 9 Ca. Cl. 2	—	—	—	—	—	—	—	—	—
Alethopteris valida (Boulay)	—	—	—	—	—	Ca. Gr. 4	—	—	—	—	—	—	—	—	—
Neuropteris heterophylla (Brongt.)	—	—	—	—	—	—	—	—	—	—	Mk.	—	—	—	—
„ *tenuifolia* (Schloth.)	—	—	—	—	—	Bo. Ca.		—	—	—	Mk.	—	—	—	—
„ *obliqua* (Brongt.)	—	—	—	—	—	Gr. 4	—	—	—	—	—	—	—	—	—
„ *acuminata* (Schloth.)	—	—	—	—	—	Gr. 4	—	—	—	—	—	—	—	—	—
Aphlebia lineare (Gutb.)	—	—	—	—	—	Bo.	—	—	—	—	—	—	—	—	—
Megaphyton frondosum (Artis)	—	—	—	—	—	—	—	—	—	—	—	—	—	No.	—
EQUISETALES															
Calamites schutzei (Stur)	—	—	Bu.	—	S. Wi.	—	—	—	—	—	—	—	—	—	—
„ *undulatus* (Sternb.)	—	—	—	—	—	Bo. Ca. Cl. 2	—	—	—	—	—	—	—	—	—
„ *ramosus* (Artis)	—	—	—	He.	Mi. St. H.	Ca.	—	—	—	—	—	—	—	—	—
Annularia radiata (Brongt.)	—	—	—	—	—	Bo. Ca.	—	—	—	—	—	—	—	—	—

Genera and Species	Belper Lawn	Alton	Naughton	Kilburn	Mickley	Black Shale	Furnace	Hospital	Deep Hard	Deep Soft	Ell	Waterloo	Dunsil	Top Hard	Clowne
SPHENOPHYLLALES															
Sphenophyllum cuneifolium (Sternb.)	—	—	—	—	—	Ca.	—	—	—	—	—	—	—	—	—
" var. *saxifragæfolium* (Sternb.)	—	—	—	—	—	Av. 9 Cl. 2	—	—	—	—	—	—	—	—	—
" *majus* (Bronn)	—	—	—	—	Mi.	—	—	—	—	—	—	—	—	—	—
" *trichomatosum* (Stur)	—	—	—	—	Mi.	—	—	—	—	—	—	—	—	—	—
LYCOPODIALES															
Lepidodendron ophiurus (Brongt.)	—	—	—	S. Wi.	—	Av. 9 Bo. Ca. Cl. 2	—	—	—	—	Mk.	—	—	—	—
" *aculeatum* (Sternb.)	—	—	—	—	—	Re.	—	—	—	—	—	—	—	—	—
" *obovatum* (Sternb.)	—	—	—	—	—	Bo.	—	—	—	—	Mk.	—	—	—	—
Lepidostrobus lanceolatus (L. & H.)	—	—	—	—	—	Gr. 4	—	—	—	—	—	—	—	—	—
Lepidophyllum majus (Brongt.)	—	—	—	—	—	Av. 9 Gr. 4	—	—	—	—	—	—	—	—	—
" *lanceolatum* (L. & H.)	—	—	—	S. Wi	St. H.	Ca.	—	—	—	—		—	—	—	—
Lepidophloios laricinus (Sternb.)	—	—	—	—	—	Av. 9 Cl. 2	—	—	—	—	—	—	—	—	—
Bothrodendron minutifolium (Boulay)	—	—	—	—	—	Gr.	—	—	—	—	—	—	—	—	—
Sigillaria discophora (König)	—	—	—	—	Mi.	—	—	—	—	—	—	—	—	—	—
" *mammillaris* (Brongt.)	—	—	—	—	—	Bo. Gr.	—	—	—	—	Mk.	—	—	—	—
" *scutellata* (Brongt.)	—	—	—	—	—	Bo. Ca. Cl. 2	—	—	—	—	—	—	—	—	—
" *rugosa* (Brongt.)	—	—	—	—	—	—	—	—	—	—	—	—	—	No.	—
" *elongata* (Brongt.)	—	—	—	—	—	—	—	—	—	—	Mk.	—	—	—	—
" *tenuis* (Achepol)	—	—	—	—	—	Gr. 4	—	—	—	—	—	—	—	—	—
" *lævigata* (Brongt.)	—	—	—	—	—	—	—	—	—	—	—	—	—	No	—
Sigillariostrobus rhombi-bracteatus (Kidst.)	—	—	—	—	—	Bo.	—	—	—	—	—	—	—	—	—
Stigmariopsis anglica (Kidst.)	—	—	—	—	—	Av. 9	—	—	—	—	—		—	—	—
CORDAITALES															
Cordaites principalis (Germar)	—	—	—	—	—	Av. 9	—	—	—	—	—	—	—	—	—
Dorycordaites palmæformis (Gopp.)	—	—	—	—	—	Av. 9	—	—	—	—	—	—	—	—	—
Cordaianthus pitcairniæ (L. & H.)	—	—	—	—	—	Bo.	—	—	—	—	—	—	—	—	—
" *volkmanni* (Ett.)	—	—	—	—	—	Av. 9	—	—	—	—	—	—	—	—	—
Cardiocarpus cordai (Geinitz)	—	—	—	—	Mi.	—	—	—	—	—	—	—	—	—	—
Polypterocarpus	—	—	—	—	—	Gr. 4	—	—	—	—	—	—	—	—	—
Artisia transversa (Artis)	—	—	—	—	—	Gr. 1	—	—	—	—	—	—	—	—	—
INCERTÆ SEDIS															
Palæoxyris helicteroides (Morris)	—	—	—	—	St. H.	—	—	—	—	—	—	—	—	—	—
ANIMALIA.															
ANNELIDA															
Spirorbis pusillus (Mart.)	—	—	—	—	—	Wi.	—	—	—	—	Mk.	—	—	—	—
CRUSTACEA															
Beyrichia arcuata (Bean)	—	—	—	—	—	—	Hl.	—	—	—	—	—	—	—	—
LAMELLIBRANCHIATA															
Carbonicola robusta (Sow.)	—	—	—	—	—	Hn.	Cl. 4 Gr.1 Hl. Wa.	—	—	—	—	—	—	—	—
" *acuta* (Sow.)	—	—	—	—	—	—	Cl. 4	—	Gr.5	—	—	—	—	—	—
" *subconstricta* (Sow.)	—	—	—	—	—	—	Gr.1 Hl. Wa.	—	—	—	—	—	—	—	—
" *nucularis* (Hind)	—	—	—	—	—	—	Hl.	—	Gr.5	—	—	—	—	—	—
" *subrotunda* (Brown)	—	—	—	—	—	Hn.	—	—	—	—	—	—	—	—	—
" *turgida* (Brown)	—	—	—	—	—	Re.	Gr.1 Hl.	—	Gr.5	—	—	—	—	—	—
" *aquilina* (Sow.)	—	—	—	—	—	Hn. Re.	Cl. 2 Wa.	—	Gr.5	—	—	—	—	—	—
" *similis* (Brown)	—	—	—	—	—	Re.	—	—	—	—	Mk.	—	—	—	—
Anthracomya wardi (Eth.)	—	—	—	—	—	—	Cl. 4	—	—	—	Mk.	—	—	—	—
" *subcentralis* (Salt.)	—	—	—	—	—	—	—	—	Gr.5	—	—	—	—	—	—
" *minima* (Ludwig)	—	—	—	—	—	Re.	—	—	—	—	—	—	—	—	—

Genera and Species	Belper Lawn	Alton	Naughton	Kilburn	Mickley	Black Shale	Furnace	Hospital	Deep Hard	Deep Soft	Ell	Waterloo	Dunsil	Top Hard	Cowne
LAMELLIBRANCHIATA—*cont.*															
Naiadites modiolaris Sow.)	—	—	—	—	—	Hn.	Cl. 2 Cl. 4 Gr. 1 Hl.	—	—	—	—	—	—	—	—
„ *triangularis* (Sow.)	—	—	—	—	—	—	Cl. 4 Hl.	—	—	—	—	—	—	—	—
„ *carinata* (Sow.)	—	—	—	—	—	Hn.	Cl. 2 Gr 1	—	—	—	—	—	—	—	—
Pterinopecten papyraceus (Sow.)	—	Bu.	—	—	—	—	—	—	—	—	—	—	—	—	—
CEPHALOPODA															
Orthoceras, sp.	—	Bu.	—	—	—	—	—	—	—	—	—	—	—	—	—
Gastrioceras listeri (Mart.)	—	Bu.	—	—	—	—	—	—	—	—	—	—	—	—	—
Goniatites	—	—	—	—	—	—	Hl.	—	—	—	—	—	—	—	—
PISCES															
Acanthodes, sp.	—	—	—	—	—	—	Hl.	—	—	—	—	—	—	—	—
Gyracanthus formosus (Ag.)	—	—	—	—	—	—	—	—	—	Mk.	—	—	—	—	—
Megalichthys hibberti (Ag.)	—	—	—	—	—	Re.	—	—	—	—	—	—	—	—	—
„ sp.	—	—	—	—	—	Re.	—	—	—	—	—	—	—	—	—
Cœlacanthus elegans (Newb.)	—	—	—	—	—	—	Cl. 2	—	—	—	●	—	—	—	—
„ sp.	—	—	—	—	—	—	Cl. 2 Hl.	—	—	—	—	—	—	—	—
Platysomus forsteri (H. & A.)	—	—	—	—	—	—	Hl.	—	—	—	—	—	—	—	—

North Staffordshire.

I examined the 'Red Rocks' in the Keele railway cutting, at Madeley, and Etruria to compare the sequence with others in the Midland district. In so doing it was found that the Etruria marls at Little Madeley contain plant-remains. Since they were considered previously to be unfossiliferous this discovery is of interest. They occurred in blackish shale above the first grit, casts of *Cordaites* sp. being especially numerous. Similar impressions were observed beneath the second grit; they resemble those found in the Keele series, in the Keele railway cutting. Beneath the fourth grit are numerous plant-remains, *Stigmaria ficoides* being especially abundant, and also pith-casts of *Calamites*, thus showing that the flora of this part of the Red Rock sequence resembles the Westphalian series.

South Staffordshire.

The ironstone nodules in the productive series are a fruitful hunting-ground if every available nodule is collected and split open. This was a task undertaken many years ago by the late Mr. Henry Johnson. His collections, partly at South Kensington, have now been dispersed and some of these nodules have been obtained and have come under our examination, of which the following is a list. They come from between the Brooch and Thick coal of Coseley, near Dudley.

PLANTÆ.

FILICALES ET PTERIDOSPERMÆ.

Sphenopteris honinghausi (Brongt.).
„ cf. *artemisiæfolioides* (Crépin).
Pecopteris miltoni (Artis).
Alethopteris lonchitica (Schloth.).
„ *decurrens* (Artis).
„ cf. *valida* (Boulay).
Neuropteris heterophylla (Brongt.).
Neuropteris obliqua (Brongt.).
„ *gigantea* (Sternb.).
„ *tenuifolia* (Schloth.).
Odontopteris.

EQUISETALES.

Calamites suckowii (Brongt.).
Calamocladus equisetiformis (Schloth.).
Annularia radiata (Brongt.).
„ *galioides.* (L. & H.).
Calamostachys.

LYCOPODIALES.
Lepidodendron ophiurus (Brongt.).
Lepidophyllum lanceolatum (L. & H.).
Cyperites bicarinata (L. & H.).
CORDAITALES, &c.
Rhabdocarpus elongatus (Kidst.).
Trigonocarpus, sp.

ANIMALIA.

MYRIAPODA.
Euphoberia ferox (Salter).
LAMELLIBRANCHIATA.
Carbonicola aquilina (Sow.).
„ *similis* (Brown).

Mr. Laurie Russ has also collected for me in the Bloxwich or northern part of the coalfield from the Shallow seam at the Sneyd Pits, Essington; where he obtained:—

PLANTÆ.

LYCOPODIALES.
Lepidodendron, sp.
Lepidostrobus variabilis (L. & H.).
Lepidophloios acerosus (L. & H.).
„ sp.
Sigillaria discophora (Konig).

ANIMALIA.

LAMELLIBRANCHIATA.
Carbonicola acuta (Sow.).
PISCES.
Rhizodopsis sauroides (Will.).
„ sp.
Megalichthys, sp.
Cœlacanthus elegans (Newb.).
„ sp.
Platysomus parvulus (Will.).
„ sp.

From the Shallow seam, Wood Farm Colliery, Bloxwich, he also obtained:—

PLANTÆ.

LYCOPODIALES.
Lepidodendron ophiurus (Brongt.).
„ *obovatum* (Sternb.).
Lepidostrobus variabilis (L. & H.).
Stigmaria ficoides (Sternb.).

ANIMALIA.

ANNELIDA.
Spirorbis pusillus (Mart.).
„ sp.
CRUSTACEA.
Carbonia, sp.

LAMELLIBRANCHIATA.
Carbonicola aquilina (Sow.).
„ *obtusa* (Hind).
„ sp.
Naiadites, sp.

PISCES.
Diplodus, sp.
Megalichthys, sp.
Rhizodopsis, sp.
Platysomus, sp.

Shropshire and Worcestershire.

The specimens sent in so far from these districts are not of sufficient importance to be recorded here.

The Excavation of Critical Sections in the Palæozoic Rocks of Wales and the West of England.—Report of the Committee, consisting of Professor LAPWORTH (*Chairman*), Mr. W. G. FEARNSIDES (*Secretary*), Dr. HERBERT LAPWORTH, Dr. J. E. MARR, Professor W. W. WATTS, *and* Mr. G. J. WILLIAMS.

[PLATE III.]

Fourth Report on Excavations among the Cambrian Rocks of Comley, Shropshire, 1910, by E. S. COBBOLD, *F.G.S.*

A FURTHER grant having been made in 1910 for the continuation of the excavations at the Comley area, I devoted my attention to making

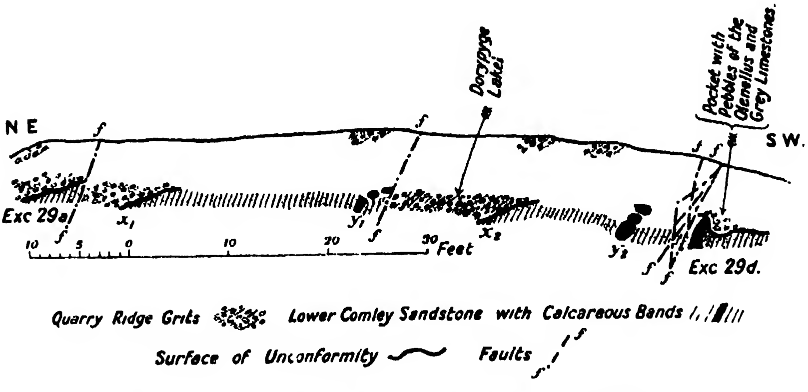
additional excavations at and near the critical locality known as Robin's Tump, working out the sequence of, and collecting and determining the fossils yielded by, the Cambrian rocks at this part of the area. The positions of these new excavations can be sufficiently identified by reference to the map published with my previous Report. In that Report[1] I pointed out that so far as the excavations had then been carried out, 'the evidence points to the conclusion that the greenish micaceous sandstone of Robin's Tump belongs to the Lower Comley Sandstone as previously defined, and that it is overlain unconformably by the Conglomeratic Quarry Ridge Grit of *Paradoxides* age.' 'Further excavations between 29*a* and 29*b* are urgently required.' To these further excavations my field work in 1910 was mainly devoted.

EXCAVATIONS AT ROBIN'S TUMP.

Excavation 29, Summit of Robin's Tump.

In order to determine the actual relations of the various strata at this critical locality, I opened out a shallow trench, some 20 yards long, connecting excavation 29*a* with 29*d* (see map, 1910, mentioned above) and extending almost the whole length of the summit. This new trench when completed gave a continuous section of the rocks concerned, and is here plotted to the scale of 12 feet to the inch, or $\frac{1}{144}$ (fig. 1).

FIG. 1.—Section exposed by excavation at the top of Robin's Tump, Comley, 1909–10, showing unconformity between the Quarry Ridge Grits and the Lower Comley Sandstone.



NOTE.—The continuous shaded parts denote the actual excavations made. The upper full line denotes the profile of the summit seen above the excavation, and the detached shaded portions the positions of the natural exposures.

Visible Evidences of the Surface of Discordant Superposition.

The left-hand (north-east) end represents excavation 29*a*. Here (as pointed out in the Sheffield Report) the Quarry Ridge Grits lie discord-

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[1] *Brit. Assoc. Report*, Sheffield, 1910.

Unconformity between the Quarry Ridge Grits and the Lower Comley Sandstone at Robin's Tump, Comley. Excavation No. 29. 1910.

FIG. 2.—Excavation No 29*a*, N E. end of the section. Length about 6 feet.

FIG 3.—Excavation No 29*d*, S.W. end of the section. Length about 4 feet. The white patches below B are pieces of grey fossiliferous limestone wedged into a cleft in the calcareous rib.

Illustrating the Report on the Excavation of Critical Sections in the Palæozoic Rocks of Wales and the West of England.

antly upon the Lower Comley Sandstone, and that the discordance is not due to faulting is rendered highly probable by the existence of cavities or burrows in the lower strata, which are filled with the material of the upper beds.

At two fresh spots along the line of the new excavation the same surface of discordance was laid bare. They are shown in fig. 1 and marked x_1, x_2. In these, as in that of excavation 29*a*, the surface of discordance rises towards the south-west.

At 29*d* the eroded surface takes a sinuous line, which is roughly horizontal and a distinct hollow is shown, but the bedding of the superior group is obscured, within the limits of the excavation, by surface débris.

It will be seen from the section, fig. 1, that the Quarry Ridge Grits occur in patches on the surface of Robin's Tump above the excavation, and may perhaps there form a practically continuous outcrop above the Lower Cambrian. The four repeats of the basement bed shown in the figure along the line of the new excavation are, in my opinion, due to little faults, some of which are actually visible in the excavation itself.

The right (south-west) portion of the section is the excavation 29*d* of the Sheffield Report. In this a rib of dark calcareous rock protrudes from the eroded surface of the Lower Comley Sandstone. This rib allows of a pocket to the right of it, the sides and base of the pocket being all visible. This pocket contained the fossiliferous rock blocks alluded to in the Third Report as 'nodules.' Further study and the new excavations made it clear that these blocks, which contain Lower Comley fossils, are actually pebbles lying in the pocket of erosion and in a matrix of Upper Comley (Quarry Ridge Grit). From the gritty matrix surrounding these pebbles I collected a free cheek of *Paradoxides*, only the pebbles themselves afforded me the Lower Comley fossils.

In a transverse cleft in the projecting calcareous rib two or three of these Lower Comley limestone pebbles are to be seen, wedged fast with the gritty matrix of the *Paradoxides* beds. Of this exposure a good photograph (Plate III., fig. 3) was secured, showing the calcareous rib, A B C; the pocket, D; and the pebbles in the cleft, under the letter B. The large block above belongs to the upper series, but is not *in situ.* The new excavation also showed two additional ribs of the calcareous rock as integral parts of the Lower Comley Sandstone, but their contact with the superior beds is not visible. These are indicated by the letters Y_1, Y_2 on the section, and from its position and thickness I am of opinion that Y_1 is the same band as that encountered in excavation No. 29*c* (Sheffield Report), where the contact was observed. Y_2 is a much thicker band, and probably not a repetition by faulting of either of the other two bands.

Visible Discordance of Dip and Strike between the Lower and Upper Series at Robin's Tump.

As pointed out in the Third Report, the beds referred to as Lower Comley appeared in excavation 29*a* to show a discordance both in dip

and in strike with respect to the local Quarry Ridge Grit, and I have secured a good photograph of that exposure also (Plate III., fig. 2). The bedding, indicated by the direction of the hammer handles, and the strikes of the rocks of both series are well shown. The dip of the upper series is about 45° and that of the lower about 55°, and the discordance of strike amounts to about 30°.

Relative Ages of the Upper and Lower Groups at Robin's Tump.

The Upper Comley (Middle Cambrian) age of the grits above the unconformity at Robin's Tump is shown by the fact that they afforded the several specimens of *Dorypyge Lakei* (Cobbold) which I obtained from one of the Grit beds near x_2, on the section, and by the *Paradoxides* cheek from 29*d* alluded to above.

The Lower Comley (Lower Cambrian) age of the lower beds at Robin's Tump may, I believe, be regarded as established by the fact that the dark calcareous bands present in them are identical in character with those that form integral parts of the Lower Comley Sandstone series elsewhere (Excavation No. 30, Sheffield Report, and Excavation No. 4, bed *a*, Dublin Report). The exact systematic position of the calcareous bands of Robin's Tump in the Lower Comley series however is unsettled. No such band was seen in Excavation No. 1 (Dublin Report), which exhibited some 50 feet of beds immediately below the Olenellus Limestone of the Comley Quarry. It seems probable, therefore, that the horizon covered by the unconformity at Robin's Tump is considerably below the top of the Lower Comley Sandstone.

SUPPLEMENTARY EXCAVATIONS IN THE NEIGHBOURHOOD OF ROBIN'S TUMP.

Excavation No. 41, South-West of Hill House.

At a point close to the letter R of the words 'Lower Comley Sandstone' on the map (see Sheffield Report) a natural exposure of green micaceous sandstone was opened up, and the following section of about 15 feet of beds, with a south-easterly dip of about 50°, was exposed.

East End of the Section.

		ft.	in.
(*a*)	Band of hard sandstone	0	6
(*b*)	Clayey material	0	9
(*c*)	Rubbly sandstone with brown patches containing one or more species of *Hyolithus*	3	9
(*d*)	Band of clayey material	1	3
(*e*)	Rubbly sandstone	2	0
(*f*)	Sandy flags, splitting well, and showing tracks of organisms on the surfaces of the beds	6	9

West End of the Section.

The tracks are well-marked depressions on the upper surfaces of the beds, with corresponding raised casts upon the lower surfaces, and are unlike anything I have yet seen in the Comley area. The burrows

obtained from Excavation No. 30 (Sheffield Report) are of the nature of tubes in the body of the sandstone.

Excavation No. 42, West of Hill House.

At a point close to the K of the words 'Wrekin Quartzite' on the map a few natural exposures of rock were visible on the surface. On opening these up, the rock was found to be a dark-blue quartzite intercalated with yellowish sandstone, but the beds are so much fractured that no definite section could be measured. The dip is nearly vertical and the general strike north and south. Several trial openings between Nos. 41 and 42 failed to reach solid rock.

Excavation No. 43, near Spring, South of Robin's Tump.

A spring is indicated on the map (Sheffield Report) about 150 yards south of Robin's Tump. The Lower Comley Sandstone found on the Saddle, in Excavation No. 29 (Sheffield Report), is traceable by surface débris up to this spring, where it is succeeded southwards by indications of shale. Openings made just above and south of the spring proved the existence of shale, with a north and south strike and a nearly vertical dip, and containing at least one band of rotten-stone, plentifully charged with *Orthis* (*Orusia*) cf. *lenticularis* (Wahl.).[2] The shales vary a good deal in hardness within a few yards and are strongly reminiscent of those of Excavations Nos. 20, 21, 25, 26 (Sheffield Report); they may therefore be assigned to the Shoot Rough Road group.

CONCLUSION.

The stratigraphical relations of the Cambrian rocks of the Comley area, as they have been laid bare during the excavations carried on under the auspices of the Excavation Committee, were summarised in my previous Report (Sheffield, 1910). But these excavations have also yielded me during their progress a large array of Cambrian fossils. Most of these Trilobites have now been described and figured by myself in papers read during the last two years before the Geological Society of London, and the Brachiopods from the higher horizons of Shoot Rough Road have been described by Dr. C. A. Matley.[3] The *Hyolithidæ* and *Brachiopoda* of the lower horizons have not yet been fully determined.

When it is borne in mind that the excavations already made deal with only a small portion of the collective area occupied by the Cambrian of Shropshire, it is evident how very desirable it is for the sake of British geology that the excavation work shall be continued.

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[2] Dr. Matley has very kindly assisted me with this identification.

[3] See Cobbold, *Q.J.G.S.*, vol. lxvi., 1910, pp. 19–51, plates iii. to viii., and vol. lxvii.

Composition and Origin of the Crystalline Rocks of Anglesey.—Sixth Report of the Committee, consisting of Mr. A. Harker (*Chairman*), Mr. E. Greenly (*Secretary*), Dr. J. Horne, Dr. C. A. Matley, *and* Professor K. J. P. Orton.

During the autumn, not long after the presentation of the last report, the map of Anglesey, in connection with which the work of this Committee has been done, was completed. The presentation of this report finds some of the analyses already incorporated into the manuscript of chapters of the forthcoming memoir, which will accompany the map.

As indicated in the report for 1910, the principal part of Mr. Hughes' rather limited opportunities for research work has been given to rocks belonging to the great Schistose Complex, chiefly with a view to determining the origin of the completely reconstructed metamorphic types.

No. 638 A. Ysgubor Fawr, Capel Soar.

	I.	II.
SiO_2	74·25	74·13
Al_2O_3	14·52	14·53
Fe_2O_3	0·76	0·73
FeO	2·02	2·06
CaO	0·06	0·10
MgO	1·09	1·08
K_2O	1·18	1·24
Na_2O	4·71	4·78
H_2O (at 110°)	0·15	0·14
H_2O (above 110°)	1·14	1·11
	998·8	99·90

This is a chloritic siliceous schist of sedimentary origin, with surviving sedimentary structures, that is the 'country rock' of the S.E. part of the central district of the Island. In it occur many quartzites and limestones, as well as the basic schist whose analysis was given in the last report. On its further side it adjoins mica-schists that are completely reconstructed.

No. 126 A. Hornblende-epidote Schist, Sarn Fraint.

	I.	II.
SiO_2	45·86	45·89
Al_2O_3	18·85	18·76
Fe_2O_3	5·73	5·70
FeO	5·43	5·45
CaO	11·61	11·68
MgO	6·73	6·80
K_2O	2·00	1·99
Na_2O	2·63	2·59
H_2O (at 110°)	0·05	0·06
H_2O (above 110°)	1·34	1·37
	100·23	100·29

This is a hornblende-epidote schist of the S.E. district, in which occur also the beautiful glaucophane-schists (analysed by Dr. Washington), and also mica-schists of disputed origin. The analysis completes a series from that district, among which are those from the pillowy diabase lavas.

No. 528 A. Clegyr Summit, Llanrhyddlad.

	I.	II.
SiO_2	59·61	59·63
Al_2O_3	19·63	19·56
Fe_2O_3	2·62	2·70
FeO	3·01	3·56
CaO	2·85	2·80
MgO	2·01	2·09
K_2O	3·60	3·52
Na_2O	3·56	3·47
H_2O (at 110°)	0·24	0·22
H_2O (above 110°)	2·51	2·54
	100·24	100·09

This is from the least altered portion of a large and remarkably uniform formation that occupies a great part of the west of Anglesey, and is very conspicuous along the western coast. It is finely clastic, but with rather peculiar structures, both on the large and the microscopic scale, and has been analysed with the view to determining whether it ought to be regarded as an ordinary sediment or as volcanic tuff. The analysis was undertaken at the especial suggestion of Dr. Horne, who examined the coast sections with the secretary in the spring. It will be seen at once that the rock is not an ordinary sediment. Incidentally, it is likely that this rock, now that its composition is known, will throw considerable light on the perplexing rocks that were analysed in the first years of the work of this Committee.

Dolomite in Carboniferous Limestone, 600 yards N. of Tros y Marian, Penmon.

	I.	II.
Residues insoluble in 20 per cent. HCl	1·27	1·23
$Al_2O_3+Fe_2O_3$	1·94	1·96
CaO	32·14	32·18
MgO	18·33	18·42
CO_2	45·96	46·05
	99·64	99·84
Per cent. of $CaCO_3$	57·39	57·46
„ „ $MgCO_3$	38·34	38·42

This rock is closely allied to the one whose analysis was published last year. It completes a series from the Carboniferous.

No. 665 A. Diorite on margin of Picrite, Llaneilian.

	I.	II.
SiO_2	48·87	48·76

This silica percentage was taken to obtain an idea of the variations of the series of intrusions to which the well-known hornblende-picrites belong. A similar rock from another district was given in the report for 1908.

Mr. Hughes is now in London, and, by the kindness of the Director of the Geological Survey, is carrying on his work for some time in the laboratory at Jermyn Street, in order to be able, while doing so, to

study the methods pursued in that institution. Some important rocks of the Schistose Complex still remain unexamined chemically. These are now being done, and, as it is hoped that the portions of the memoir in which they will be described will be written during the coming winter, it is likely that this group of analyses will complete the work of this Committee. When certain older analyses, some published, some unpublished, are added to those done under its auspices, the body of chemical evidence bearing on the problems presented by the crystalline rocks of Anglesey will be unusually large.

The Committee ask to be reappointed for one year more, using during that time the balance remaining, but without any further grant of money.

Characteristic Fossils.—Report of the Committee, consisting of Professor P. F. KENDALL (*Chairman*), Mr. W. LOWER CARTER (*Secretary*), Professor W. S. BOULTON, Professor G. COLE, Dr. A. R. DWERRYHOUSE, Professors J. W. GREGORY, Sir T. H. HOLLAND, *and* S. H. REYNOLDS, Dr. M. C. STOPES, Mr. COSMO JOHNS, Dr. J. E. MARR, Dr. A. VAUGHAN, Professor W. W. WATTS, *and* Dr. A. SMITH WOODWARD, *appointed to consider the preparation of a List of Characteristic Fossils.*

THIS Committee, appointed at the Sheffield Meeting, held a preliminary meeting of the members present at Sheffield at the Victoria Hall, on September 7, 1910, when the subject was discussed and suggestions were made as to the lines on which the work should be carried out. It was resolved to consult teachers of geology and to submit to them the suggestions of the Committee.

The Chairman and Secretary have been in correspondence with the members of the Committee, and have submitted to them the following questions—

(1) What should constitute a characteristic fossil?

(2) How many lists would be needed for various grades of students?

(3) How many fossils should be included in each list?

(4) To what extent should the geological formations be subdivided for this purpose?

(5) To what classes of geological teachers should the circular be sent?

(6) Do you approve of the preparation of preliminary lists of formations and fossils by a small sub-committee of experienced teachers, which should be circulated round the Committee for revision and suggestions before the several divisions are submitted to specialists?

Answers to these questions have been received from nearly all the members of the Committee and when they are completed and tabulated they will be embodied in a circular of suggestions which will be sent to teachers of geology for their consideration.

The Committee ask to be reappointed with a grant of 5*l.* for printing and postages.

Occupation of a Table at the Zoological Station at Naples.—Report of the Committee, consisting of Professor S. J. HICKSON (*Chairman*), Mr. E. S. GOODRICH (*Secretary*), Sir E. RAY LANKESTER, Professor A. SEDGWICK, Professor W. C. MCINTOSH, Dr. S. F. HARMER. Mr. G. P. BIDDER, Dr. W. B. HARDY, *and* Professor A. D. WALLER.

THE British Association table at Naples has been occupied during the past session by the Hon. Mary Palk, Mr. J. Bayley Butler, and Mr. W. O. Redman King.

The following reports of the work done by these investigators have been received.

The Hon. Mary E. Palk reports: 'I occupied the British Association table at the Naples Zoological Station for six months from November to May. I was engaged in examining a large body of unknown function occurring within the Zoœcium of certain Bryozoa, notably in *Flustra papyrea* (Pallas), which displays a peculiar structure and will take no differential stain. I was not able to come to any definite conclusion as to the nature of this body, which appears to be an organ, not a parasitical growth, but hope eventually, by comparing similar structures in various Bryozoa, to be able to elucidate the matter.'

Mr. J. Bayley Butler, University College, Dublin, reports: 'I beg to report that I occupied the British Association table at Naples from January 12 to March 20. I desire to thank the Committee for having granted me the use of their table, and I wish at the same time to express my sense of indebtedness to the members of the staff of the Naples Zoological Station for the assistance they so readily accorded to me. Two lines of investigation were pursued, in both of which further work is necessary before writing a final report. I shall continue the experiments during the year and make due acknowledgment to the British Association when publishing the results. In the first place I was studying the rate and character of the regeneration in appendages of Isopods (two species of Idothea) under ordinary conditions in an aquarium, with a view to determining any alteration that changes in the environment may effect. Secondly, I carried out some few experiments on the reaction to light of the large Copepod *Anomalocera Patersoni* (Templeton). This species differs in its behaviour from most Copepods in plankton, since it swims only in the surface layers of the sea (at any rate in the adult) and does not appear to take part in the general periodic depth migrations. I believe that the investigation of its reaction to light and gravity will prove of scientific value.'

Mr. W. O. Redman King reports: 'I have been in Naples now just five weeks (July 18). The work has been going on fairly satisfactorily. So far I have been for the most part making experiments upon the temperature coefficients of the velocity of development of Sphaerechinus and Arbacia. These have not been hitherto worked out fully and satisfactorily. I had wanted to try some experiments upon the effect of acids and alkalis on sea-urchin hybrids, in order to test Tennent's work; but the above-mentioned sea-urchins are the only forms that are

ripe just now, and they do not cross with sufficient readiness for my purpose. I expect to remain in Naples until September 6.'

A meeting of zoologists was held in London on March 31 to consider what steps should be taken to maintain a table at the Zoological Station at Naples for investigators of British nationality. As a result of that meeting a promise has been received of financial assistance, not exceeding 100*l.*, extending over a period of two years, pending arrangements to be made for placing the British table on a permanent footing.

As some time may yet elapse before the necessary arrangements can be completed, the Committee ask for reappointment by the British Association with a grant of half the usual amount—50*l.*

Index Generum et Specierum Animalium.—Report of the Committee, consisting of Dr. HENRY WOODWARD (*Chairman*), Dr. F. A. BATHER (*Secretary*), Dr. P. L. SCLATER, *the* Rev. T. R. R. STEBBING, Dr. W. E. HOYLE, *the* Hon. WALTER ROTHSCHILD, *and* Lord WALSINGHAM.

SINCE the 1910 Report systematic search through literature has proceeded up to the letter E. Further, a group of especially troublesome and difficult books has been dealt with, *e.g.*:—

Oken's 'Isis,' 41 vols., 1817-48;
Froriep's 'Notizen,' 102 vols., 1821-50;
Ersch and Gruber, 'Allgem. Encyclopædie,' 103 vols., 1818-50;
and many other volumes have been indexed out of the general order as asked for or required—as, for instance, the works of Jacob Huebner, which are now in Mr. Sherborn's hands in hope that he may obtain some further information as to the dates of their publication.

The search for rare literature continues, and Mr. Sherborn desires to thank Dr. Karpinski for obtaining for him the second volume of the Trudui of the St. Petersburg Mineralogical Society, 1831; Dr. Bashford Dean and Mr. O. F. Cook for a complete set of 'Brandtia' 1896-97, both of which works will find a resting place in the British Museum (Nat. Hist.) when done with. He also desires to thank Mr. Tom Iredale for much valuable help in obscure bird genera.

The following papers have been written in connection with the Index:—

'On the dates of publication of Costa's "Fauna del Regno di Napoli" 1829-1886,' 'Ann. Mag. Nat. Hist.' (8) v., 1910, 132.

'A collation of J. C. Chenu's "Illustr. Conch." and a note on P. L. Duclos' "Hist. Nat. gén. et part. Coquilles"' (with Mr. Edgar A. Smith), 'Proc. Malac. Soc.,' ix., March 1911.

'Note on John Curtis' "British Entom."' (with Mr. J. Hartley Durrant), 'Entom. Month. Mag.,' xlvii., April 1911.

Your Committee confidently recommend their reappointment, and earnestly ask the Association further to support this valuable work by a grant of 100*l.*

Belmullet Whaling Station.—Report of the Committee, consisting of Dr. A. E. SHIPLEY (*Chairman*), Professor J. STANLEY GARDINER (*Secretary*), Professor W. A. HERDMAN, Rev. W. SPOTSWOOD GREEN, Mr. E. S. GOODRICH, Dr. H. W. MARETT TIMS, *and* Mr. R. M. BARRINGTON, *appointed to investigate the Biological Problems incidental to the Belmullet Whaling Station.*

THE Committee have received the following preliminary report from Mr. S. T. Burfield, who has proceeded to the fishery for four months:—

I arrived at the station of the Blacksod Whaling Company on June 13. This station was opened in 1910, and is situated in Elly Bay in the Belmullet Peninsula, Co. Mayo. The 'fishing' began this year in the middle of May, and at the time of my arrival twelve whales had been caught. This catch is as shown in the following table:—

Species	Total Number	Length (average)
		Feet
Balænoptera musculus (Linn.) . .	7	61½
B. borealis (Lesson)	2	44
B. sibbaldii (Gray)	1	71
Physeter macrocephalus (Linn.) . .	2	57

As will be seen neither Right whales (*Balæna biscayensis*) nor Humpbacks (*Megaptera longimana*) had been captured, although both these species are found off the west coast of Ireland.

Since I have been at the station up to the time of writing this report (August 1) twenty-seven whales have been brought to the station by the two whaling steamers of the Company. These have all been examined to some extent. Three of the twenty-seven were Blue whales (*Balænoptera sibbaldii*, Gray), and the remaining twenty-four were Fin-whales (*B. musculus*). Right whales (*Balæna biscayensis*) and Rudolphi's Rorquals (*Balænoptera borealis*) are generally caught earlier in the season only, and it is not very likely that specimens will be taken again this year. It is quite possible, however, that Sperm whales (*Physeter macrocephalus*) and Humpbacks (*Megaptera longimana*) may yet be caught.

From the whaler's point of view the present season has been distinctly bad. Although the actual catch has been comparatively small, the yield of oil per whale has been rather above the average. Generally speaking a gravid female gives the best yield, whilst a female with a suckling is thin.

Some information has been obtained on subjects of general interest in relation to whales and the whale 'fishery,' such as—(*a*) the general factory procedure in connection with the extraction of the oil and manufacture of guano and cattle food; (*b*) the whaler's point of view as to the probable extinction of the larger species of whales; (*c*) breeding and migration, especially the definite routes kept by some whales; (*d*) the blowing of whales; (*e*) the probable two varieties of *B. musculus*.

The presence of whales off the coast seems to depend to a great

extent on the weather. A long spell of fine calm weather appears to send the whales further out, whereas dull, cloudy, and rainy weather brings them in. This is especially the case with the Mystacocetes, and is probably almost entirely due to the movements of the plankton on which these whales chiefly subsist. Of course in very rough weather the whalers find it impossible to handle the whales even though they may be seen.

I. *Measurements.*

A definite and, wherever possible, complete set of measurements was taken of every whale examined. It was found impracticable to obtain the distance between the tips of the tail-flukes as intended, as most of the flukes are cut off directly the whale is captured to reduce the resistance when towing into the station.

It is intended to examine these measurements more closely later on, but a few general conclusions may be noted.

Balænoptera musculus.—Average length of whole catch = 61 feet 9 inches. Number of males = 12. Number of females = 12. Average length of males = 61 feet 1 inch. Average length of females = 62 feet 6 inches. From these results it seems, as is generally supposed, that about equal numbers of each sex are captured, and that the females are slightly larger than the males. As far as can be ascertained without going into the figures closely, the general proportions of these Rorquals agree with those already published by other observers.

B. sibbaldii.—The average length of the three Blue whales examined was 76 feet 2 inches, but of these one was much smaller than the other two. All these were females.

All of the above measurements only refer to the whales captured after my arrival. The total lengths of those caught before this have been obtained, however, so that the averages will be more trustworthy when these are taken into account as well. Unfortunately the sex of the individuals is not noted at the station. Corresponding measurements were taken as nearly as possible in exactly the same way, but the weight of the animal distorts the shape of the body when on the flensing slip, so that exact correspondence cannot always be obtained in some measurements.

II. *External Form.*

The general form of all the specimens seen agreed with previous descriptions of the species. In two cases in particular among the *Balænoptera musculus* the pectoral fins on either side did not correspond exactly in size. In each case that on the left side was distinctly the larger.

In both *B. musculus* and *B. sibbaldii* the pectorals ended in a fairly sharp tip, and this tip had an upward turn in the Blue whales, but this was very slight in two of the specimens. In many of the whales the fins had various small irregular notches round the tip. These appear to be injuries, although it is hard to say what could have caused them. In one case a larger notch was noticed at the base of the dorsal fin.

The dorsal fin of *Balænoptera sibbaldii* was found to be more pointed

at the tip than that of *B. musculus*, but in both cases the exact shape varies somewhat.

The tail fin could not be examined in the adults for the reasons stated above, but in the fœtal specimens mentioned below the concavity of the tail fin was particularly noticeable. The surface of the tail is concave beneath, and in the fœtus the flukes themselves are bent downwards so as to bring the tips towards each other.

III. *Colour Descriptions, &c.*

As most, if not all, the whales must have been dead several hours (from six to twelve) before being examined, great care had to be exercised in noting actual colours. It is well known that all the colours darken after death. In the case of contrasting light and dark (in patches, &c.) the relations would probably not be very much altered for some time, so that variations in the arrangement of patches of colour were noted. In the case of *B. musculus* variations in colour-details were found to be very common. The asymmetrical jaw-coloration is, however, quite definite and constant and the dark patches on the under side are often confined to the furrows of the breast folds.

Specimens of the skin were taken (*a*) from tail where the second layer of black integument is very thick; (*b*) from the body so as to include some of the peculiar white spots; (*c*) from breast folds of *B. sibbaldii* to include a portion of a bright yellow patch; (*d*) from breast folds to include portion of pink coloration (? blood or pigment).

IV. *Hairs.*

The distribution of these on both *B. musculus* and *B. sibbaldii* was found to be substantially the same as described by D. G. Lillie (Proc. Zool. Soc., 1910). They occur (i) along top of head, (ii) along the side of lower jaw, and (iii) as vertical rows at tip of lower jaw. The actual numbers in any one of these positions appear to vary somewhat.

A similar distribution was also found in the fœtal specimens of *B. musculus* and *B. sibbaldii* examined.

The hairs appear to be rather more numerous on tip of mandible in the case of *B. sibbaldii* than in *B. musculus*.

Specimens of hairs with underlying tissues were taken for further examination.

V. *Jacobson's Organ.*

In the case of *B. musculus* the two grooves under the tip of snout which represent the openings of this organ generally have short canals leading out of the hinder ends of the grooves. These canals are from ½ to 1 inch in length when they exist, but in some cases there are no canals at all. Such canals, so far as I have seen, are absent in *B. sibbaldii*.

These ducts appeared to be in much the same state in the fœtus examined. In the case of a fœtus 8 feet long of *B. sibbaldii*, a short duct was present on the right side, but no duct could be detected on the left side.

Specimens of the ducts with surrounding tissue were taken both from adult and fœtus.

VI. *The Eye.*

The general appearance of the eye *in situ* was noted. It is very similar in *B. musculus* and *B. sibbaldii.* There is a definite series of furrows in the integument round the eye. The skin all around the eye is almost invariably of the uniform dark blue-grey colour. The eyelids are fairly full.

It was found almost impossible, in the short time which could be given to the examination in any one specimen, to observe the musculation and innervation of the eye *in situ* on account of the large amount of fatty tissue, &c., round the eyeball.

Specimens were taken from adults, and whole eyes from the fœtus also, and on closer examination of these more information may be obtained.

VII. *Contents of Stomach.*

The contents of the stomach were examined in nearly every case.

B. musculus.—In the first three whales examined (captured on June 29 and July 3) the stomach and pharynx were found to contain large numbers of fish (presumably herrings) up to 5 inches in length. In all other whales examined up to the present the stomachs have contained a varying quantity of small red crustacea. In the intestines these are reduced to a terra-cotta coloured fluid in which the eyes of the crustacea appear as floating blue spots. The fæces consist of a semi-solid terra-cotta mass. Specimens of the contents of the stomach both in the case of fish-feeding and crustacea-feeding have been preserved.

B. sibbaldii appear never to feed on anything but the small crustacea (the 'krill' of the whalers).

VIII. *Parasites.*

1. THE BALEEN of both *B. musculus* and *B. sibbaldii* is generally largely covered with the Copepod *Balænophilus unisetus.* These are apparently always to be found on *B. sibbaldii.* In the case of *B. musculus* they are sometimes almost absent. Both the nauplius larvæ and adults can be detected. When comparatively few of these parasites are present they are generally on the inner part of the baleen plates. If larger numbers of the younger stages are present, they appear to be chiefly on the outer part of the plates.

2. THE BODY.—*B. sibbaldii*: No external parasites on body wall were found in any specimen. *B. musculus*: In some cases the parasitic Cirripede *Pennella balænopteræ* (Kov. & Dan.) was found. The external portions of these averaged about 6 inches in length. They are generally found in a position not far behind the ear, but in some cases were found fairly high up on the side nearer the tail. The greatest number found on one whale was five.

3. THE GUT.—No parasites were found in the gut of *B. musculus.* In some parts of the gut of *B. sibbaldii* large numbers of parasites were found. They appear superficially to be of two kinds, one of which is very like the *Echinorhynchus* described by Professor Collett in *Balænoptera borealis* (Proc. Zool. Soc., 1886).

IX. *Fœtus.*

Efforts have been made to obtain a very small fœtus, but with no success up to the present. Five fœtus have been examined. Four of these were *B. musculus* and one was *B. sibbaldii.*

A full set of measurements has been taken of these as for adults. All these were too large for embryological work, the smallest being nearly five feet in length, and the largest about eight and a half feet.

Several interesting specimens were taken from these, *e.g.*, (*a*) Pectoral fin (for the extra digit found by Kükenthal); (*b*) Ovaries and ducts; (*c*) Heart and great vessels; (*d*) Bodies which appear to be thyroids; (*e*) Jacobson's organ; (*f*) Part of jaw to show beginning of whalebone.

X.—Just inside the tip of lower jaws two small white spots were noticed in *B. musculus*. In these is a small valve-like flap partly covering a small opening. These openings lead into ducts each about an inch long extending backwards and slightly downwards. The openings of these canals are about half an inch apart.

At present I am uncertain what these organs are, as I can find no reference to them in literature.

Aug. 1, 1911. S. T. Burfield.

The Committee consider that the investigation of the whales brought into this whaling station on the coast of Ireland is of great importance for the knowledge of the natural history and anatomy of these mammals. They hope to report more fully next year on the results obtained when the specimens secured by Mr. Burfield will have been examined. There already seems to be a diminution in the number of whales off the West Coast of Ireland, and hence the present whale fishery is unlikely to be continued for more than three or four years.

The Committee consider that it is imperative that the present investigations should be continued next year. The Association gave a grant of 30*l.*, which Mr. Barrington has generously supplemented by a gift of a like amount. This will pay the expenses of the present year, perhaps leaving a balance of 10*l.*

The Committee ask for reappointment, with a grant of 50*l.*, for the season of 1912, when it is hoped to send an investigator (probably Mr. Burfield) as soon as the fishery opens, so that any catch of the rare *Balænoptera borealis* and *Physeter macrocephalus* may be investigated.

Experiments in Inheritance.—Fourth Report of the Committee, consisting of Professor W. A. Herdman (*Chairman*), Mr. R. Douglas Laurie (*Secretary*), Professor R. C. Punnett, *and* Dr. H. W. Marett Tims. (*Drawn up by the Secretary.*)

The experiments have yielded results bearing upon several problems:—

(1) In the first place all my yellow mice appear to be heterozygous in respect of their yellow coat colour, none which have been fairly tested breeding true to yellowness, but on the other hand giving off-

spring which include, in addition to yellows, a proportion of individuals whose colour is other than yellow.

	Yellow	Non-yellow
Yellow × yellow (25 matings) =	53	28
Yellow × other colours (53 matings) =	124	113

The anomalous heredity of the yellow coat colour in mice is thus confirmed.

(2) In the matings yellow × yellow the proportion of yellow to non-yellow individuals in the F_1 generation is 2 : 1 instead of the familiar 3 : 1. This harmonises with the results of Cuénot, Castle, and Durham, and suggests that the yellow-bearing gametes do actually conjugate, but that the zygotes so produced perish.

(3) In harmony with the latter suggestion is the fact that the number of mice in a litter, when both parents are yellow, is less than when either or both of the parents are of some other colour :—

	Average No. of young
Yellow × yellow (25 matings)	3·64
Yellow × non-yellow (53 matings)	4·75
Non-yellow × non-yellow (103 matings)	4·75

Matings in which one or both parents are albino are not included. This quite marked difference is not found by Miss Durham in the mice which she bred, but is in agreement with the observations of Cuénot and Castle.

(4) In the matings yellow × other colour the F_1 generation shows the expected normal approximate equality of yellow and other coloured individuals.

The above results, and certain others, will, it is hoped, be set out in detail during the present year. The Committee therefore ask to be reappointed for one year without a grant.

The Formulation of a Definite System on which Collectors should record their Captures.—Report of the Committee, consisting of Professor J. W. H. TRAIL (*Chairman*), Mr. F. BALFOUR BROWNE (*Secretary*), Dr. SCHARFF, Professor G. H. CARPENTER, Professor E. B. POULTON, *and* Mr. A. G. TANSLEY.

THE Committee were appointed last year and have dealt with the matter by correspondence. They have decided that the Watsonian County and Vice-County system should be recommended, but the details are still under discussion and it is proposed, before issuing a final report, to consult the field clubs and natural history societies of Great Britain and Ireland with a view to acquainting them with the ideas of the Committee and hearing from them any suggestions they may be inclined to make.

The Committee therefore ask for reappointment.

Zoology Organisation.—Report of the Committee, consisting of Sir E. RAY LANKESTER (*Chairman*), Professor S. J. HICKSON (*Secretary*), Professors G. C. BOURNE, J. COSSAR EWART, M. HARTOG, W. A. HERDMAN, *and* J. GRAHAM KERR, Mr. O. H. LATTER, Professor MINCHIN, Dr. P. C. MITCHELL, Professors E. B. POULTON *and* A. SEDGWICK, *and* Dr. A. E. SHIPLEY.

THE Committee summoned a meeting of zoologists to consider what steps should be taken:—

1. To maintain a table at the Zoological Station at Naples for investigators of British nationality.
2. To ensure the continuation of the work that has been done by a Committee of the British Association in the compilation of an 'Index Generum.'

By the permission of the Council the meeting was held in the rooms of the Royal Society in London on March 31. There was a good attendance of representative zoologists.

The Committee ask to be reappointed.

The Mammalian Fauna in the Miocene Deposits of the Bugti Hills, Baluchistan.—Interim Report of the Committee, consisting of Professor G. C. BOURNE (*Chairman*), Mr. C. FORSTER COOPER (*Secretary*), Drs. A. SMITH WOODWARD, A. E. SHIPLEY, C. W. ANDREWS *and* H. F. GADOW, *and* Professor J. STANLEY GARDINER, *appointed to enable* Mr. C. FORSTER COOPER *to make an examination thereof.* (*Drawn up by the Secretary.*)

THIS expedition arrived in Jacobabad in the middle of January 1911, and after obtaining the necessary camels, stores, and servants proceeded into the Bugti territory and arrived in five days at Kumbhi. Here the fossiliferous beds were located and four weeks spent in working out the exposures each side of Kumbhi. The beds were then followed out to the eastward round the Zen Koh range with varying success, the strata in parts being much turned up and unsuitable for the preservation of fossils.

During the last four weeks of the expedition an important bone bed was discovered at Churlando of a different character of deposition from the other beds. Owing to the difficult nature of the excavation, the lack of suitable labour, and to the fact that very heavy rains delayed the work for a week, much still remains to be done in this bed, and the interesting specimens obtained warrant its further exploration.

A considerable collection of mammalian remains was obtained from the various localities which is now in process of development and cleaning in the laboratories of the natural history branch of the British Museum prior to its detailed examination and description.

The fauna consists largely of Anthracotheres, of which group many species are represented in the collection. Remains of extinct orders of

Rhinoceros are also common, including an interesting new genus now in process of examination.

Fragments of small Artiodactyles also occur, but owing to the character of the deposits small forms are seldom preserved. The condition of the remains is unfortunately poor as a rule, partly owing to the weathering and partly to the damage done by contemporary crocodiles at the time of deposition, the remains of these animals being abundant as well as the marks of their teeth on the fossils obtained.

The expedition received much kindness and help from the Government officials, as well as from the ruling chiefs of Dera Bugti.

The Zoology of the Sandwich Islands.—Twenty-first Report of the Committee, consisting of Dr. F. Du Cane Godman *(Chairman)*, Mr. D. Sharp *(Secretary)*, Professor S. J. Hickson, Dr. P. L. Sclater, *and* Mr. Edgar A. Smith.

The Committee were appointed in 1890 and have been annually reappointed. Since the last report they have published two parts of the 'Fauna Hawaiiensis,' and there now remains only a general or introductory part to complete the work. The preparation of this part is well advanced.

The Committee ask for reappointment, with the expectation of making a final report next year.

Feeding Habits of British Birds.—Third Report of the Committee, consisting of Dr. A. E. Shipley *(Chairman)*, Mr. H. S. Leigh *(Secretary)* Professors S. J. Hickson, F. W. Gamble, F. E. Weiss, J. Arthur Thomson, *and* G. H. Carpenter, *and* Messrs. J. N. Halbert, C. Gordon Hewitt, Robert Newstead, Clement Reid, A. G. L. Rogers, *and* F. V. Theobald, *appointed to investigate the Feeding Habits of British Birds by a study of the contents of the crops and gizzards of both adults and nestlings, and by collation of observational evidence, with the object of obtaining precise knowledge of the economic status of many of our commoner birds affecting rural science.*

The investigation of the feeding habits of the rook, starling, and chaffinch has been continued during the past year. Some of the correspondents whose names appear in the report for 1909 have again sent birds to the Secretary. The Committee again desire to express indebtedness to them for their kind assistance.

During the seven months (June 1, 1910, to December 31, 1910) forty birds have been received, the number being made up as follows: rooks eight, chaffinches eighteen, starlings fourteen. No birds have been received during 1911. Each bird is accompanied by a form filled in by the correspondent giving such particulars as are set forth in the report for 1909. The contents of the gizzards of 218 rooks,

381 starlings, and forty chaffinches have been examined up to May 31. The evidence obtained from the examination of these specimens is not sufficient to form a correct estimate of the economic value of any one of the three birds under investigation. It is hoped, however, that the work now in hand will soon be completed and the results arranged for publication, and further that the scope of the inquiry will be much increased.

A grant of 5*l.* was again made to the Committee by the Association in 1910. As no further financial assistance had been obtained up to the end of July the work has been seriously handicapped; it has been carried on during the past year with the help of a loan of 25*l* from the Manchester University. An application has been made to the Development Commissioners for an increased grant, so that the extent of the investigation can be increased, and they have just recommended that an interim grant of 250*l.* be made during the current year. This will enable the work to be continued at Manchester on a larger scale than hitherto, but will not allow of any great development. The Committee ask for reappointment without a grant.

Marine Laboratory, Plymouth.—Report of the Committee consisting of Professor A. DENDY (*Chairman and Secretary*), Sir E. RAY LANKESTER, Professor A. SEDGWICK, Professor SYDNEY H. VINES, *and* Mr. E. S. GOODRICH, *appointed to nominate competent Naturalists to perform definite pieces of work at the Marine Laboratory, Plymouth.*

SINCE last July the table has been occupied by Mr. J. S. Dunkerly, who spent a few days at Plymouth in January last for the purpose of making investigations on the Choanoflagellate Protozoa. The use of the table was granted to Dr. Lyster Jameson for three weeks in May and June last, but Dr. Jameson was obliged to postpone his visit. The use of the table has also been granted to Dr. John Tait for the month of August 1911, for his investigations on the application of physiological methods to the classification of invertebrate animals.

Map of Prince Charles Foreland.—Report of the Committee, consisting of Mr. G. G. CHISHOLM (*Chairman*), Dr. R. N. RUDMOSE BROWN (*Secretary*), Sir DUNCAN JOHNSTONE, *and* Mr. E. A. REEVES, *appointed to complete the Map of Prince Charles Foreland, Spitsbergen, based on the Surveys of* 1906, 1907, *and* 1909 *made by* Dr. W. S. BRUCE.

THE original map was constructed on a scale of two inches to a mile, with the heights and depths in feet and fathoms. This was reduced to a scale of 1 : 100,000, with heights and depths on the metric system. The original of this reduction was sent in final form to the

Prince of Monaco, who will publish it from the Oceanographical Institute in Monaco. A photograph of that map has been presented to the British Association as a report of the work.

A second reduction on the same scale (1: 100,000) is being prepared in feet and fathoms for publication in Britain.

Reports of the field work in connection with the map have already been given at the meetings in Dublin and Sheffield.

Gaseous Explosions.—Interim Report of the Committee, consisting of Sir W. H. Preece (*Chairman*), Mr. Dugald Clerk *and* Professor Bertram Hopkinson (*Joint Secretaries*), Professors Bone, Burstall, Callendar, Coker, Dalby, *and* Dixon, Drs. Glazebrook *and* Harker, Professors Petavel, Smithells, *and* Watson, Lieut.-Col. Holden, Captain Sankey, Mr. D. L. Chapman, *and* Mr. H. E. Wimperis, *appointed for the Investigation of Gaseous Explosions, with Special Reference to Temperature.*

During the session 1910-11 the work of the Committee has been continued, but from various circumstances—partly break-down of apparatus and partly pressure upon the time of various investigators—only two Notes have been read. Three meetings have been held, two at Mr. Dugald Clerk's rooms at Lincoln's Inn Fields and one at the Finsbury Technical College, Leonard Street, City Road, London, E.C. The meetings have been excellently attended and two Notes have been presented and discussed, viz., No. 19, on 'The Volumetric Heat of Carbonic Acid and Air up to 1000° C.,' by Dugald Clerk, and No. 20, on 'The Cyclical Changes of Temperature in a Gas-Engine Cylinder at and near the Walls,' by Professor E. G. Coker.

A great deal of other work is in hand, which will be included in a full report to be given next year.

The Organisation of Anthropometric Investigation in the British Isles.—Report of the Committee, consisting of Professor Arthur Thomson (*Chairman*), Mr. J. Gray (*Secretary*), *and* Dr. F. C. Shrubsall.

The Committee, through lack of funds, have not been able themselves to carry out any measurements of the adult population of the British Isles.

It is however satisfactory to note that the scheme embodied in their 1908 report, which is published by the Royal Anthropological Institute, is being widely adopted throughout the British Empire and elsewhere.

The Australian Association for the Advancement of Science has resolved that the scheme of this Committee be adopted in all anthropometric survey work carried out in Australia. At the present time an extensive and very complete survey of the school children of Victoria

is being organised, for which the scheme of this Committee has been adopted.

The Committee hope to come to an agreement, as far as possible, with the German and Vienna Anthropological Societies, who are about to hold an Anthropometric Conference at Heilbronn, with the view of securing uniformity in methods of measurement.

The Committee ask to be reappointed with a grant of 5*l.* to cover expenses of correspondence, &c.

A Prehistoric Site at Bishop's Stortford.—Report of the Committee, consisting of Professor W. Ridgeway (*Chairman*), Rev. Dr. A. Irving (*Secretary*), Dr. A. C. Haddon, *and* Dr. H. W. Marett Tims, *appointed to co-operate with a Local Committee in the excavation thereof.* (*Drawn up by the Secretary.*)

The early facts which suggested the prehistoric interest of this site were brought to light in the excavation of a boggy patch of ground in the high flank of the Stort Valley at nearly 300′ O.D., the idea being the formation of a 'lily-pond' to improve the ground above Maple Avenue as a building-site. In this way, by the care of the experienced workman, F. Curtis, the complete horse skeleton (on which a paper was read last year to Section H by myself, the cogent geological facts being treated in a paper read before Section C) was uncovered, in the exact position indicated in the photographs. The 'finds' on the actual site, taken altogether, suggest its occasional and repeated occupation by nomadic peoples (attracted by the high-level spring, to which the physiographic details of the locality are due) after the fashion of a modern gipsy-camp.

In 1910 the following gentlemen formed themselves into a local committee for the further exploration of the site where the horse skeleton was unearthed: Rev. A. Irving, D.Sc., B.A. (*Chairman and Secretary*); J. Dockray, Esq., M.D., B.Sc.; W. Hartigan, Esq., M.D.; Rev. H. Hollingworth, M.A.; A. W. Nash, Esq., M.A.; F. S. Young, Esq., M.A.; Mr. H. G. Featherby, C.E.; Mr. Joseph Day (the proprietor). In response to the appeal made at the time subscriptions to the amount of 7*l.* 2*s.* were received. Of this sum 6*l.* 2*s.* was expended for skilled labour and contingent expenses. Subsequent subscriptions have brought the amount (paid and promised) up to 11*l.* 18*s.* The total expenditure up to the end of July 1911 has been 7*l.* 2*s.*, leaving a balance of 4*l.* 16*s.* in the hands of the Secretary for further work.

In the autumn of 1909 the geological structure of the hill was more fully determined by two borings on Mr. Day's land and two on Sir John Barker's land above. The facts thus ascertained confirm generally those previously known from the two well-sections at the waterworks 350 yards distant. (See 'Mem. Geol. Survey,' vol. iv., p. 449.) In May 1910 the pond was drained and the bottom of it thoroughly explored. The mud was first scraped off the bottom and passed by two

workmen through a screen under the supervision of Mr. H. G. Featherby and myself. It was then dug all over to the full depth of a shovel without finding the slightest trace of anything that could be associated with a modern horse. A considerable addition was made, however, to previous prehistoric 'finds,' and a Holocene molluscan fauna was discovered in the bog silt. The silt was in places strewn with shelly débris, and it was only with the greatest care that complete specimens could be secured for identification. Of these the following have been identified by Mr. B. B. Woodward, F.G.S., of the British Museum (Nat. Hist.): *Helix nemoralis*, *Hygromia* (*Helix*) *hispida*, *Vitræa nitidula*, *Succinea putris*, *Pyramidula rotundata*, *Helix arbustorum*. *Clausilia bidentata* was, I think, also found, but unfortunately got crushed at the museum before it was identified. A small bivalve was fairly frequently met with, which I have identified at the Jermyn Street Museum as *Pisidium*.

Of the fossil shells mentioned above it may be pointed out that six at least of them have been noted in the Holocene deposits at Staines[1]; six have been described from the Barnwell Gravels[2]; and three are described by Von Hauer as characteristic of the diluvial loess of the Rhine and the Danube.[3]

Reasoning from the geological data, the writer of this report was led at an early stage of the investigation to conclude that the formation of this bog must have taken place in early post-glacial times: that inference seems to be confirmed by the palæontological evidence.

In the paper read last year before Section C[4] palæolithic and neolithic flint implements and 'cores,' fragments of baking-tiles, fragments of pottery (neolithic and bronze periods), primitive bricks moulded with human hands, an ingot of crude bronze, fragments of charcoal, and a variety of erratic boulders are enumerated. These were recovered by turning over the materials which had been wheeled out of the pond-basin, together with several missing small bones of the skeleton. The tile-fragments and mammalian bone-fragments are numerous; a caudal vertebra of *Bos*, and a few molars of *Bos* and *Equus* were also found; and the vegetable contents of the beast's paunch, reduced to a state of peat (one cake of it strongly stained with phosphate of iron), partly within, partly without, the trunk of the skeleton, the skeleton having as a whole been deformed and the vertebral column thrown into a curve by the invasion of the bog by a later landslide on the side where the feet lay.

Owing to the adverse weather of the early spring and the indifferent health of the Secretary nothing further was attempted; and when the fine weather set in time was lost through the difficulty of obtaining the services of the specially experienced workman who excavated the pond-basin. Little progress, therefore, has been made, but the results obtained have added to our knowledge, and go to confirm the inferences which had been drawn from the facts previously known.

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[1] See Kennard and Woodward (*P.G.A.*), vol. xix. (p. 252 ff.).

[2] B. B. Woodward, *ibid.*, vol. x. (p. 356 ff.).

[3] See *Die Geologie* (Hölder, *B.A.*, Wien), by F. Ritter von Hauer (p. 696).

[4] *Brit. Assoc. Reports*, 1910, p. 616.

Method of procedure:—

(i) A trench four feet deep was driven to the right, and a similar trench to the left, from the line of the present streamlet below the pond well into the undoubted London clay *in situ* behind the 'rubble-drift';

(ii) A trench has been dug below the pond up the line of the ancient gully, which was found completely choked with *remanié* clay of the character of blackish bog-silt. At a depth of four feet below the present surface of the hill-slope a fine angular flinty shingle with several erratics was dug into, clearly marking the line of the ancient gully which the stream had cut into the flank of the hill in post-glacial times. This was observed to be in a line with similar indications of the ancient line of the stream, across which the trunk of the horse was seen to have lain when it was removed in 1909. It may be said that no one who has had extensive observation of the Eocenes could recognise these phenomena as having anything to do with the London clay, which constitutes the solid geology of the hill behind, as it had been proved in the trial-borings of the autumn of 1909, and exposed in recent excavations for building along the same contour of the hill slope. Of the 'finds' from this trench on the arterial line of the ancient gully the following list is given:—

A. Mammalian remains:—

Four very rotten fragments of split marrow-bone, one lower premolar of *Equus* (broken).

B. Human artefacts:—

Fragment of a gritstone hand-mill, two fragments of extremely primitive half-baked tiles; one clinker; five or six (apparently) 'pot boilers'; about a dozen flints, possibly recognisable as 'cores' or 'scrapers,' two of them 'patinated.'

The erratics from the three trenches include:—

Two good-sized boulders of volcanic ash, small boulder of weathered dolerite, a sub-angular fragment of jasper, four moderate-sized pebbles of vein-quartz, two rolled fragments of coarse white gritstone, a rolled fragment of Röthlschiefer? (Permian), a slab of red ferruginous sandstone (Jurassic?) two inches thick; a slab of white fine-grained sandstone (Keuper?) one inch thick.

To these must be added flints without number, nearly all in a highly weathered condition, some extremely so, several showing the etching action of organic (humus) acids, while others bear unmistakably the marks of long surface-exposure (possibly during the great Miocene elevation) before they were picked up by the early ice, which deposited the glacial drift which caps the hill, and from which these erratics must have been brought down, since the deposit is at a higher level than the true chalky boulder-clay of the district. Eight at least of these highly altered flints have been not only bleached but *scaled*, after the fashion of those brought years ago by Captain H. G. Lyons, F.R.S., from the Egyptian desert. Scarcely a fresh flint was found in the course of the excavations, and it may be inferred that these extremely altered flints have been transported in many cases by ice-agency from

Mercian regions far beyond the present chalk escarpment to the basin of the Thames.

The Committee ask to be reappointed. A grant of 5*l.* is asked for to supplement the local fund, for the purpose of continuing the work of excavation above the pond, and (with the proprietor's permission) extending the operations into the adjoining land.

NOTE.—This year (1911) extensive excavations connected with public works have been made in the peaty alluvium and the underlying glacial shingle of the Stort Valley. Most valuable 'finds' have come to hand from these, including pleistocene mammalian remains, as well as bones of *Equus* and *Bos longifrons*, the former tallying remarkably with the bones of the Maple Avenue skeleton. But as these excavations do not fall under the purview of your Committee, they are dealt with in a separate paper communicated to Section H.

The Lake Villages in the Neighbourhood of Glastonbury.—Report of the Committee, consisting of Dr. R. MUNRO (*Chairman*), Professor W. BOYD DAWKINS (*Secretary*), Professor W. RIDGEWAY, Sir ARTHUR J. EVANS, Dr. C. H. READ, Mr. H. BALFOUR, *and* Mr. A. BULLEID, *appointed to investigate the Lake Villages in the Neighbourhood of Glastonbury in connection with a Committee of the Somersetshire Archæological and Natural History Society.* (*Drawn up by* Messrs. ARTHUR BULLEID *and* H. ST. GEORGE GRAY, *the Directors of the Excavations.*)

THE second season's exploration of the Meare Lake Village by the Somersetshire Archæological and Natural History Society began on June 5, and was continued for three weeks under the joint supervision of Messrs. A. Bulleid and H. St. George Gray. The ground excavated was situated in the same part of the village and was directly continuous with last year's work.

The digging included the examination of the remaining portion of Dwelling-mound VII., the whole of Mound VIII., and portions of Mounds IX., X., and XI.

With reference to the construction of the above mounds, two, *i.e.*, Mounds VIII. and IX., had special points of interest and call for mention here. Taken as a whole, however, this part of the work has been up to the present time somewhat disappointing, as little additional information has been gained regarding the structure generally apart from that already acquired at the Glastonbury Lake Village.

Mound VIII. was of medium size, consisting of five floors and situated N.E. of Mound VII. No hearth was discovered associated with the two uppermost floors, which were separated with much difficulty throughout. An interesting series of eight superimposed baked clay hearths was, however, found belonging to Floors iii., iv., and v., surrounded by thick layers of fire-ash. The hearths varied from 2 feet 6 inches to 5 feet 3 inches in diameter.

Mound IX. was of large size, consisting apparently of two floors, and was only partially examined. Below the clay was a thick layer of black earth composed of charcoal, fire-ash, and débris containing quantities of bones of animals and fragments of pottery. Under the black earth a well-preserved platform of timber was disclosed, bordered by the remains of the wattled wall of a circular dwelling. This timber was chiefly arranged in a N.E. and S.W. direction, and by far the larger number of the wall-posts were made of squared oak, a feature not noticed in the dwellings previously examined.

The relics discovered this season were hardly as numerous as last year. A summary of them is appended.

Bone.—The bone objects were not very numerous. The most interesting specimen is a smooth pin without head, having a long recess, or notch, along the middle of the shaft. A similar object was found with Late-Celtic remains on Ham Hill, S. Somerset (Taunton Museum), and another on the Roman site at Iwerne, Dorset (Pitt-Rivers Museum, Farnham, Dorset). The other specimens include two tibiæ of horse (sawn and perforated), two large polishing-bones, pins, a dress-fastener, part of a drill-bow, and two objects of worked bird-bone.

Worked Carpal and Tarsal Bones of Sheep or Goat.—A large number of 'bobbins' and other objects, showing signs of considerable use, have been found, especially in Mound VII. where so many weaving appliances were discovered. Many of these bones are perforated in different directions; others have transverse markings, some deeply grooved and very smooth.

Worked Shoulder-blades of Ox and Horse.—At the end of last season no fewer than thirty-two of these objects had been found, all in Mound VII. Four more were collected from the same dwelling this year; and two others in adjacent mounds. Two of those found in Mound VII. are ornamented with large examples of the dot-and-circle pattern. In all instances the bones are smooth, and the longitudinal spine had been cut down considerably. Many of them are perforated at the articular end (probably for suspension). They have been found where weaving implements are abundant, but their use remains to be explained.

Crucibles.—Fragments of two found this year.

Bronze.—Fifteen objects of this material were uncovered this year, but no fibulæ are included. There are three finger-rings, one ornamented by a cable pattern, two rivets (one of a new type), an awl, three thin moulded bosses, part of a belt-fastener, and a large part of the bordering of a perishable scabbard, including the bulbous chape. Perhaps the most interesting remains of bronze is a pair of pins with disc-shaped heads and arched stems.

Flint.—In addition to a number of flakes, a scraper and two or three finely worked knives have been found.

Glass and other Beads.—The beads are numerous and varied. Nine were found last season; eighteen specimens this year. The collection includes two polished bone ring-beads. Six of the beads are of a yellow opaque glass, and two pale blue (also opaque). One of the finest specimens is a ring-bead of clear sea-green glass, and two are dark blue. A

small blue bead is ornamented round the sides by a continuous wave pattern; two globular beads of clear white glass are ornamented in yellow, one by a spiral device, the other by a herring-bone pattern. The smallest bead is a little more than an eighth of an inch in diameter.

Antler.—The numbered objects of this material have now reached the total of seventy-three, twenty-four being found this season, including three antlers of roe-deer, one bearing knife-cuts, another being shaped as a knife-handle. Nothing of exceptional interest has been found this season, many being pieces of cut antler impossible to name. The two hammers found have not been perforated for fitting handles. Several examples of the so-called 'cheek-pieces,' perhaps used in connection with the bridles and bits of horses, have been found, but the precise use of many of these objects is very doubtful, and their shaping and perforating varies very considerably.

Weaving-combs of Antler.—Again we have a fine series, bringing the former number of twenty-one up to a total of thirty-five. Mound VII., which must have been a weaving establishment, contributes no fewer than twenty-nine of the number. No dwelling in the Glastonbury Lake Village produced more than nine of these combs. One example is dentated at both ends, with twelve and thirteen teeth respectively. The largest, having ten teeth, is 7¾ inches long. Several of them are ornamented with transverse and oblique lines, and one, at least, with dots-and-circles.

Iron.—The objects of iron are mostly fragmentary and much corroded as usual. The 'finds' include a chisel, knife, file, and an awl in its handle of antler; also an earth-anvil. The latter was found on the top floor of a mound, and only a foot deep below the flood-soil, through which, owing to its weight, it may probably have sunk subsequently to the occupation of the village.

Kimmeridge Shale.—Objects of this material have this season been increased from twelve to twenty-one, and they are more numerous than in the neighbouring village of Glastonbury. These objects are parts of lathe-turned armlets, with three exceptions, viz., a set of three roughly cut heavy rings, which may have been used in connection with horse-harness. In section one of the armlets (half) measures no less than 21 mm. by 16 mm.

Lead and Tin.—Last season three net-sinkers of lead were found, to which one has been added this year. The first object of tin has been found, viz., a small whorl (? bead) ornamented with encircling lines of small punch-marks.

Querns.—Compared with the Glastonbury Lake Village these are plentiful at Meare, but the circular rotary querns are rare as compared with the saddle-shaped specimens, of which some well-preserved examples have been found.

Other Stone Objects.—Parts of circular blocks of stone have been found, slightly recessed on one face and having a narrow rim; they show signs of intense heat and may be parts of moulds for casting thin bronze. A large assortment of stone hammers and whetstones have been found.

Sling-bullets.—Several of the baked clay sling-bullets typical of the period have been collected. Under the clay floors of the mounds three groups of selected ovoid stones were discovered, the numbers being 99, 182, and 347, respectively.

Spindle-whorls.—The former number of twenty-three has this season been increased to forty-three. Most of them are formed from discs of lias; a few are of baked clay, two being very large.

Pottery.—Shards of pottery have been very numerous—some three or four hundredweight. All of them have been scrubbed and preserved, being sorted under the numbers of the dwellings. Several complete pots may probably be built up some day. The proportion of ornamented fragments is high as compared with those from the neighbouring village, and a great many new and highly ornate designs have been added to the collection. Very little ornamented pottery was discovered in the deepest layers; and much of it bearing typical Late-Celtic designs was found just under the flood-soil. The coarser plain pots were generally found in the black earth and brushwood below the clay floors.

Human Remains.—Two pieces of skull and one bicuspid tooth.

Animal Remains.—Found abundantly. The perforated boars' tusks and canine teeth of large dog were no doubt used as personal ornament. The enormous number of bones of young animals indicates that the inhabitants of this marsh village must have been great meat-eaters. The remains of beaver and otter are frequently met with; and also a considerable number of bird-bones.

Artificial Islands in the Lochs of the Highlands of Scotland.—Report of the Committee, consisting of Dr. R. MUNRO *(Chairman),* Professor J. L. MYRES *(Secretary),* Dr. T. H. BRYCE, *and* Professor W. BOYD DAWKINS, *appointed to investigate and ascertain the Distribution thereof.*

THE Committee desire in the first place to express their indebtedness to their local correspondent, Dom. F. Odo Blundell, of St. Benedict's Abbey, Fort Augustus, N.B., at whose suggestion the present inquiry was put in hand. Dom. Blundell had already wide experience of the problems which it raises, and has placed all his knowledge and energy at the disposal of the Committee.

As the extent of country covered by this inquiry is very large, the Committee thought that the first step would be to ascertain the number of these islands which are already known as artificial by their immediate neighbours, but are not otherwise recorded. Accordingly a circular was prepared and printed, and so far 246 copies have been issued.

The replies show that great interest is taken in the subject and many excellent suggestions have been offered as to how the inquiry can be made more complete. As was to be expected, the replies to the circular in many cases gave details of islands which were already recorded in Dr. Munro's 'Scottish Lake Dwellings'; but allowing for these, we are now enabled to add to that list no fewer than fifty-three

fresh examples: and there is every reason to hope that the present shooting season will afford opportunities for recording many more. Also local scientific and literary societies will make this a subject for discussion at their meetings.

A few extracts from some of the more instructive letters may be of interest. Dr. Th. Johnston, M.A., Assistant to Sir John Murray, in the 'Lake Survey of Scotland,' writes: 'In the great majority of the lochs which I have visited, artificial islands exist, either as "islands" or more often as "cairns" more or less submerged. The existence of causeways is frequent, and generally, as you may know, they have a bend or turn in them, so that strangers or enemies would probably step off into deep water. These islands have all a very similar structure and formation as far as surface inspection goes, and no doubt if you examined them in your diving dress you would find them much the same in construction as Cherry Island' (the popular name for Eilean Muireach in Loch Ness).

Rev. D. Macrae writes from Edderton, Ross-shire: 'In my former parish of Lairg, Sutherland, I always considered one at least of the two islands at the south end of Loch Shin to be artificial. It bears a striking resemblance to fig. 1 on page 2 of your notice. . . . I am also reminded that Loch Brora contains what appears to be an artificial island and that further north at Loch Clibrig there is an island with a distinct causeway to the shore.'.

Mr. O. H. Mackenzie, of Poolewe, suggests that 'the only thing to do would be to send some antiquary round to make a thorough examination and report. . . . As there are boats on all those lochs you mention, there would be no difficulty to encounter.'

Mr. Alex. Curle, Secretary of the Historical Monuments Commission, expressed his views as follows: 'In the first place I may assure you that nothing but personal inspection will procure at all satisfactory information, especially in the far North, where as the native says: "There is thousands of time," and where replying to a letter, and far less a circular, is a feat rarely attempted. In my Sutherlandshire Inventory I noted, for your personal benefit, any artificial islet that came to my knowledge . . . but as I said before, to get satisfactory evidence the trained eye is absolutely necessary. I accept nothing unseen.' Similar advice comes from Mr. O. H. Mackenzie, of Poolewe, as quoted above. He and all the other Highland proprietors who have so far been asked have readily promised to assist the inquiry.

Interesting replies have also been received from Mr. Hew Morrison, LL.D., Public Librarian, Edinburgh; Dr. Anderson, Oban; Mr. Angus Grant, Drumallan, Drumnadrochit; Major McNab, Liphook, Hants; and Mr. Erskine Beveridge, LL.D., who in a long letter described seven islands in North Uist, and ten probable ones in the Isle of Mull.

The difficulty, above noted, of determining whether an island suspected to be artificial really is so—seems to require that a competent judge be sent to inspect the islands as suggested in two of the letters. Of course one of the chief difficulties of the inquiry is the sparse population of the districts where the islands are thought to be numerous. It is in fact difficult to find anyone with whom to correspond, but the

above extracts show that where suitable correspondents are found the existence of these islands can be traced. The arrival of the shooting tenants will to some extent remedy this.

The Committee ask to be reappointed with balance in hand, and if possible a further grant, in order that a paper as exhaustive as possible may be prepared for the meeting of 1912 in Dundee. There seems to be a peculiar fitness that a paper on these prehistoric remains of North Britain be read at that meeting.

Subjoined is the list of islands so far suggested as artificial. Several correspondents have not yet returned the replies which they promised, and as the present is only an interim report, it was considered unnecessary to trouble them.

Name of Loch	District	Name of Correspondent
Loch-na Ban More	Eigg	Rev. F. McClymont
Loch Kinellan *	Strathpeffer	Mr. H. E. Corbett
Loch Craggie	Lairg	Mr. John Campbell
Loch Clibrig	Lairg	Rev. Mr. Macrae
Loch Migdale	Lairg	Mr. Alex. Curle
Loch	North of Scourie	,, ,,
Loch Dun na Killie	South Uist	Rev. A. McDougall
Loch na Faoillen *	,, ,,	,, ,,
Loch a Mhoullin *	,, ,,	,, ,,
Loch Ard Bornish	,, ,,	,, ,,
Loch Ceann a'Bhaigh	,, ,,	,, ,,
Loch Alt-a-Briac	,, ,,	,, ,,
Loch Druidibeg	,, ,,	,, ,,
Loch Ailsh	Sutherland	Mr. D. F. Macdonald, factor
Loch Vaa	Aviemore	Mr. Angus Grant
Loch Pit-youlish	,,	,, ,,
Loch Quien	Bute	Rev. Mr. Hewitson
Loch Tollie	Poolewe	Mr. D. Mackenzie
Loch Kernsary	,,	,, ,,
Loch Mhic M-Riabhaic	,,	,, ,,
Loch Ach-an-darraich	Plockton	,, ,,
Loch Meiklie	Glenurquhart	Mr. W. Mackay
Loch Tigh Choimhead	Tongue	Mr. Hew Morrison
Loch Lundavra	Lochaber	Dr. Miller, M.D.
Loch Kinnord *	Aberdeenshire	Mr. J. MacPherson
Loch Ruthven *	Inverness	Mr. R. McLean
Loch Lora	Lairg	Mr. D. Mackenzie
Loch Calder	Caithness	,, ,,
Loch Monkstadt	Skye	Mr. K. Macdonald
Loch an Duin	Barra	Rev. W. Mackenzie
Loch nan Eala *	Arisaig	Mr. Nicolson, C.B.
Loch Arkaig (partly)	Lochaber	Dr. Th. Johnston
Loch Hoil	Aberfeldy	,, ,,
Loch Essan	Perthshire	,, ,,
Loch Deroulich	,,	,, ,,
Loch of Cliff	Unst, Shetland	,, ,,
Loch Achnahinneach*	Kintail	Mr. George Forbes, Fernaig
Loch Glass *	Sutherland	Rev. W. Fraser
Loch Ussie *	Strathpeffer	Mr. H. Fraser, Academy, Dingwall
Loch Achilty *	,,	,, ,,
Loch Morie *	,,	,, ,,
Loch Beannachan	Ben Wyvis	Mr. Colin Campbell, Shiel

Those marked with an asterisk (*) have good illustrations available.

Name of Loch	District	Name of Correspondent
Loch an Duin * . .	Portain, N. Uist	Mr. Erskine Beveridge, LL.D.
Loch an Duin * . .	Broinish ,,	,, ,,
Loch Obisary (two islands) . . .	,, ,,	,, ,,
Loch Mor Balesbare (two islands) . . .	,, ,,	,, ,,
Loch nan Clachan * .	,, ,,	,, ,,
Loch Eashader . .	,, ,,	,, ,,
Loch Aonghuis * . .	,, ,,	,, ,,
Loch Oban Trumisgarry *	,, ,,	,, ,,
Loch nan Gearrachan (two islands) . .	,, ,,	,, ,,
Loch Fada * . . .	Coll	,, ,,
Loch Ghille-Caluim .	,,	,, ,,
Loch Rathalt . .	,,	,, ,,
Loch Urbhaig * . .	,,	,, ,,
Loch an Duin * . .	,,	,, ,,
Loch Cliad (two islands)	,,	,, ,,
Loch nan Conneachan *.	,,	,, ,,
Loch Anlaimh . . .	,,	,, ,,

Those marked with an asterisk (*) have good illustrations available.

The Excavation of Neolithic Sites in Northern Greece.—Interim Report of the Committee, consisting of Professor W. RIDGEWAY (*Chairman*), Professor J. L. MYRES (*Secretary*), Mr. J. P. DROOP, *and* Mr. D. G. HOGARTH.

THE Committee, having no grant this year, have been unable to co-operate directly in the work for which they were originally appointed. They are able to report, however, that Messrs. Wace and Thompson have been able to make further surface observations in Northern Greece and Macedonia, and have applied for a permit to examine an important early site in the neighbourhood of Salonica.

The Committee ask to be reappointed with a further grant.

Notes and Queries in Anthropology.—Report of the Committee, consisting of Dr. C. H. READ (*Chairman*), Professor J. L. MYRES (*Secretary*), Mr. E. N. FALLAIZE, Dr. A. C. HADDON. Mr. T. A. JOYCE, *and* Drs. C. S. MYERS, W. H. R. RIVERS, C. G. SELIGMANN, *and* F. C. SHRUBSALL, *appointed to prepare a New Edition of 'Notes and Queries in Anthropology.'*

THE manuscript of the new edition is now nearly ready for press; but it has not been possible to complete the work of the Committee before the date at which report has to be made. The Committee therefore ask to be reappointed, with the balance in hand and leave to expend on the new edition, in accordance with the original agreement, the sum recovered by the sale of copies of the last edition through the agency of the Royal Anthropological Institute.

The Age of Stone Circles.—Report of the Committee, consisting of Dr. C. H. Read (*Chairman*), Mr. H. Balfour (*Secretary*), Lord Avebury, Professor W. Ridgeway, Dr. J. G. Garson, Sir A. J. Evans, Dr. R. Munro, Professor Boyd Dawkins, *and* Mr. A. L. Lewis, *appointed to conduct Explorations with the object of ascertaining the Age of Stone Circles.* (*Drawn up by the Secretary.*)

Excavations were renewed at Avebury Stone Circle in the spring of the present year, and, as in former years, Mr. H. St. G. Gray, Curator of the Taunton Museum, was placed in charge of the work, to conduct the excavations under the general directions of the Committee. In selecting the particular sites most likely to yield important results the Committee were impressed with the great desirability of conducting excavations in the *fosse* to the east of the causeway, on the opposite side of which cuttings had been made in the fosse in previous years. The owner of this portion of the circle, Captain Jenner, readily gave his permission, but, unfortunately, the strenuous opposition of the occupying tenant caused this scheme to fall through. It is most desirable that thorough exploration of the fosse and causeway should be made at this point, but for the present the matter must remain in abeyance, and this important part of the examination of the earthwork must be postponed, perhaps, for a few years. In consequence of this primary scheme having been rendered abortive, the Committee agreed to extend further the exploration of the S.W. portion of the fosse, and to this the season's work was practically confined. The results obtained have borne out the views based upon the previous excavations, and have strengthened the belief that the monument dates from Neolithic (probably late-Neolithic) times. The work has been conducted by Mr. Gray in a very thorough manner, and the records, plans, and photographs form a very complete series of permanent value. Mr. Gray's detailed report is appended, giving a full account of the work done and of the relics found. The thanks of the Committee are due to those who have generously responded to an appeal for subscriptions to eke out the grant made by the British Association, the amount collected (a detailed statement of which is appended to the report) being very satisfactory. The Committee wish also to thank Lord Avebury and Captain L. C. D. Jenner for permission to excavate on their property, and the Rev. J. G. Ward, Vicar of Avebury, for assistance rendered in procuring labourers. Captain Jenner also assisted the work by the useful loan of a number of planks, &c.

Although it is unlikely that excavations at Avebury can be renewed next year, the Committee ask to be reappointed with a view to a complete survey of the Avebury circle and earthworks being made by Mr. Gray, who has already prepared a survey-plan of the S. and S.W. portion. For this it is hoped that a grant of 20*l.* will be made by the Association. This will not cover the expenses, but it is trusted that the sum may be slightly augmented by subscriptions. No perfectly reliable plan of this most important monument exists at present.

The balance of the fund collected, being allocated by the subscribers to special excavation work for the examination of the *vallum* and the 'cove,' will not be available for the survey.

THE AVEBURY EXCAVATIONS, 1911. By H. ST. GEORGE GRAY.

I. *Introductory Remarks.*

Having given a general description of Avebury and its surroundings in the former reports,[1] the present account will be almost confined to the excavations conducted at Avebury from Monday, April 24, till Wednesday, May 10 (the filling-in continuing till Saturday, May 20). It should be stated that all the cuttings so far made are situated on Lord Avebury's property. Not only were the 1911 excavations filled in this season, but similar work was completed in regard to the explorations of 1908 and 1909. Fencing now encloses these areas, so that in the course of a couple of years nearly all traces of the excavations should be obliterated.

A maximum number of fifteen men was employed this season, sixteen being engaged in 1909 and eleven in 1908. The weather was fairly favourable, not more than eight hours being lost on account of rain during the period of the work. This season we took the necessary precautions, and were not hindered by falls from the sides of the silting as the digging penetrated into the lower strata of the great fosse.

Sectional diagrams of the fosse, &c., were made as the work proceeded, in which the deposits of silting were indicated, as well as the position of every object of importance found. The scale map of the area excavated in 1908 and 1909 has been redrawn to include this season's work. An average section of the southern fosse was given in the 1908 report (p. 406), and, being fairly representative of the other sections, it will be unnecessary to publish another on the present occasion.

Twenty satisfactory photographs (half-plate) were taken during the season, and these, added to twenty-two taken in 1909 and sixteen in 1908, not only show the progress and chief features of the excavations, but also include general views, together forming a somewhat complete photographic survey of 'the Temple' of Avebury.

One of the most interesting features of the 1909 excavations was the discovery of the entrance-causeway of solid chalk, a little to the east of the modern road into Avebury from the south, connecting the Kennet Avenue with the interior of the monument. The causeway proved to be about 24 feet wide, and on its east margin we dug some test trenches and found that the solid chalk gradually receded as if sloping off to meet the upper margin of the walls of the fosse in the form of rough steps, not always well defined.

With these results before them the members of the Committee were anxious to follow up these observations and to excavate the rounded (or squared?) end of the fosse at its termination on the east side of the causeway; and it was felt that being close to the entrance there would be an increased probability of finding a larger number of relics in the silting of the fosse in this position. The silting is not high here, and probably has at no time been under cultivation,

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[1] *Brit. Assoc. Reports*, 1908, pp. 400-413; and 1909, pp. 271-284.

so that the labour entailed in re-excavating this part would be proportionately less than in the fosse on the south and south-west of the monument. As stated elsewhere, although Captain Jenner (the owner) was willing that this work should be done, his tenant was found to be bitterly opposed to excavations being carried out under any conditions. Fortunately for archæological field-work such obstacles do not often present themselves. The disappointment, however, had to be faced, and, pending further negotiations, it was decided that an excavation should be made across the S.W. fosse, on Lord Avebury's property, of greater extent than those made in former years.

II. *General Observations on Cutting* VIII., *through the S.W. Fosse,* 1911.

This cutting was 30 feet long, and was afterwards extended in the middle 6 feet further west in order that a ledge, or bench, might be cut, upon which the lower strata of silting could be thrown in clearing the bottom of the fosse. The eastern margin of the cutting (in the middle of the silting) was 235 feet in a direct line from the gateway on the western side of the road at the Kennet Avenue entrance, and 98 feet from the middle of the western margin of Cutting I. (1908) across the fosse.

The surface of the silting at the point selected for this year's work was practically level (the variation being less than 6 inches). It is stated, on the authority of the oldest inhabitants of Avebury, that the whole of the S.W. quarter of the fosse had been cultivated as arable land some sixty years ago, and this would account for the flatness here. As previously stated,[1] it is said by the local people that a quantity of loamy tenacious material had been brought to this part of the fosse, and especially near the high-road from the site of the new bridge across the Kennet stream on the Devizes road.

While the excavations were in progress a large sectional diagram was plotted along the eastern margin of Cutting VIII. fosse, and continued in a S.W. direction to include the crest of the vallum, the foot of the exterior slope, and the boundary-hedge beyond, and in a N.E. direction to cover the turf-clad counterscarp of the fosse and part of the central plateau, including one of the standing sarsen stones (height 8·5 feet) of the great outer circle. The horizontal distance from the north side of the stone to the north upper margin of the boundary-hedge proved to be 183 feet, and from the middle of the fosse to the crest of the vallum about 78 feet.

This section showed that the central plateau was 12 feet, and the crest of the vallum 31 feet, above the turf level of the fosse. After re-excavating the fosse the bottom was found to be 18·7 feet deep below the surface of the silting on the eastern margin, and consequently 49·7 feet below the crest of the vallum. Supposing that the crest of the vallum was originally about 5 feet higher, the total vertical height from the floor of the fosse to the summit of the embankment

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[1] *Brit. Assoc. Reports*, 1909, p. 279.

could not have been less than 55 feet—probably the largest dimension of the sort obtainable in any prehistoric earthwork in Britain.

Along the line of section on the eastern margin of the cutting a narrow trench (3 feet wide) was dug from the south side of the cutting towards the crest of the vallum, to ascertain the position of the hewn chalk. It was found to run at an angle of 28° for a considerable distance, at a depth of from 1·1 to 1·6 feet below the surface of the turf. This digging was carried far enough to find clear traces of the old turf line under the great vallum, and to reach the solid chalk at a depth of about 2·2 feet below its surface. From this trench and the level of the central plateau we were able to obtain a fairly accurate estimate of the *original* depth of the fosse in this part, that is, its depth below the ground level at the time of the construction of Avebury. This estimate gives the depth of 31·5 feet for the fosse in the midlde, and a height of about 16 feet for the vallum above the old surface line at the present time; but the original height of the embankment, as previously stated, was undoubtedly greater.

At the close of the excavations we found that on the line of section both the escarp and the counterscarp of the fosse, revealed by the removal of all the silting, had faces inclined at different angles. The following was the inclination of the solid chalk sides:—

Escarp.—Lower 5 feet, inclination 90°; middle 18 feet, 62°; upper part, 28°.

Counterscarp.—Lower 8 feet, inclination 74°; middle 12 feet, 50°; upper part, 28°.

III. *The Excavation of Cutting VIII., Fosse.*

A length of 30 feet of fosse was excavated, but as a considerable batter to the faces of the silting had to be left to avoid any risk of falls, it was only possible to uncover completely a length of 21·5 feet of the floor. Unlike the floor in the former cuttings, the bottom was found to be very irregular and far from level. The fosse was deepest along the eastern margin, viz., 18·7 feet below the surface of the silting. It gradually rose as we continued the work of re-excavation westward. The depths of the fosse below the surface of the silting along the western margin of the cutting were[8]: Maximum, 16·8 feet; minimum (in the south corner), 15·3 feet; in the middle of the fosse, 16·3 feet. The maximum width of the bottom of the fosse was 15 feet at the east end, and the minimum width in the middle about 9·5 feet.

Two sectional diagrams of the floor were made, showing that the levels taken varied to the extent of 2·95 feet, which was very surprising. This may probably be accounted for by the poor quality of the rock, which consisted of a soft, smooth, rotten, pale greenish-grey chalk of the zone of *Rhynchonella Cuvieri.* (The common fossil, *R. Cuvieri*, was found close to the floor.) This poor chalk occurred also in the lowest part of the profile of the fosse, with occasional solid blocks of whiter chalk projecting beyond it, as seen in some of the photographs.

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[8] The turf level in the middle of the silting was five inches higher on the east margin than on the west margin of the cutting.

The deposits of silting must now be described, beginning at the bottom with the pure chalk rubble. The material was found, as in the other cuttings, to cover the whole of the solid faces of the fosse, and its accumulation must have been very rapid when the ditch fell into neglect. Relics found in this deposit would probably all belong to the first decade or so following the disuse of the monument. This silting was no doubt the result of natural causes, *i.e.*, the scaling of the profile of the fosse in frosty and rainy weather, and the falling down of material forming the embankment, which in all probability was not at that time turf-clad. Comparatively small quantities of turf and mould would, in the course of construction, be thrown up with the chalk to form the great vallum, and the occasional fall of the dark mould from the bank would be sufficient to account for the concave streaks, or seams, in the chalk rubble of the fosse, which were even better defined in the 1911 section than in the cuttings previously made. The lowest seam of mould, which extended right across the cutting in one part, reached at the point of greatest concavity to within five feet of the bottom of the fosse. The three seams on the south side of the silting were, for a length of several feet, exceptionally noticeable.[4] On the eastern margin the depth of chalk rubble in the middle of the fosse was ten feet. This rubble was very large at about 2·5 feet from the bottom, especially in the middle of the ditch, but it became rather smaller again on the bottom. Pieces of iron pyrites were commonly found in the rubble, but very little flint was observed, and most of the pieces were very small. Fragments of charcoal were occasionally met with. At the top of this deposit the lumps of chalk were found cemented together, no doubt by means of carbonate of lime contained in water which had percolated through the upper silting, consolidating the chalk and rendering it as durable as the hardest concrete. Its thickness was perhaps hardly as great as in Cuttings I. and II. of former years.

The upper deposits of silting consisted, from the top downwards, as in the other cuttings, of (1) turf and turf-mould, (2) surface silting, (3) mixed silting, and (4) fine mixed silting, their thickness on the eastern margin being, in the middle of the accumulation, 0·65, 3·35, 2·7, and 2 feet respectively. This gives a total depth of silting above the chalk rubble of 8·7 feet. On the western margin, where the fosse was shallower, these deposits were represented by a thickness of 7·7 feet. Dividing the surface silting from the mixed silting was a thin seam of small pieces of chalk which was traced nearly the whole way along the cutting. So much has been said in the former reports on these deposits that it will be unnecessary to make repetition here.

Above the chalk rubble two distinct patches (not seams extending across the cutting) of dark mould and very fine chalk were traced, the lower one practically throughout the length of the digging. The higher patch was at an average depth of 5 feet, the other about 7·2 feet, below the surface, in what are called the 'mixed silting' and the 'fine mixed silting' respectively. Maximum thickness of each, 0·6 foot. Evidence

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[4] See similar seams of mould in the fosse of Wor Barrow, Handley, Dorset (*Excavations in Cranborne Chase*, iv., plates 250, 251).

of fire was distinctly traceable, and charcoal in small pieces was observed in both deposits. In the lower patch a piece of the burr of a small red-deer antler, a bit of burnt bone, and fragmentary animal remains were found, and the charcoal included remains of beech (identified by Mr. Clement Reid); the objects described later under No. 160 were also collected from the same material. The prehistoric pottery, No. 167, was found in the upper deposit of burnt material. It is a question if these deposits do not indicate some sort of occupation when the fosse had silted up to these respective levels.

IV. *Relics found in Cutting VIII., Fosse.*

147, 148, 150, 151. Fragments of rims, &c., of glazed and unglazed mediæval pottery. Depths from 2·2 to 2·6 feet in the surface silting. (Several other pieces of mediæval pottery were found, but only the best samples were preserved.)

149. Two small tines of deer (in poor preservation). Depth six feet in the mixed silting.

152. Fragment of soft New Forest ware, painted and slightly ornamented; Roman. Depth 4·2 feet near the top of the mixed silting.

153. Fragment of brown pottery, Romano-British. Found as No. 152.

154. Finely chipped flint knife, of plano-convex section, worked on the convex face only and along both edges; the butt-end shows the outer crust of the flint core from which the implement was struck; length 61 mm., maximum width 30 mm., maximum thickness 8·5 mm. It was badly fractured by being struck by an iron pick, but has been neatly repaired. Depth 5·7 feet in the mixed silting.

155. Two fragments of light brown pottery, Romano-British. Depth 4·3 feet near the top of the mixed silting.

156. Small iron cleat (for shoe or sandal); length 22 mm., with narrow base (width 7·5 mm.) and the usual projecting points for attachment. Depth 4·7 feet in the mixed silting.

157. Two fragments of mediæval pottery, with band of ornament. Depth 3 feet in the surface silting.

158. Fragment of brown pottery, with faint striations, Romano-British. Depth 4·5 feet in the mixed silting.

159. Flat and rounded disc of sandstone. Depth 6·8 feet in the chalk rubble.

160. Part of the beam of a shed antler of red-deer, with burr, brow- and bez-tines complete; unworked. Depth seven feet in the fine mixed silting in a patch of burnt material. Close to the antler were found part of a dog's jaw and a boar's tusk.

161. Greater part of the rim and sides of a black earthenware saucer, Romano-British. It cannot be completely restored. The fragments were found strewn over a considerable area. Depth 3·5 feet in the mixed silting.

162. Bronze fibula, Roman, having a semi-circular bow of plano-convex section, the rounded upper surface being ornamented longitudinally by a beaded pattern of the character usual in brooches of this

type; the nose, consisting of a rounded knob, appears to have been broken and replaced by a knob of a different metal; the pin is hinged, with an iron axis; the head of the bow terminates in a plate bearing the inscription AVCISSA (unfortunately the initial A has been broken off); length 49·5 mm. Found near the western margin of the cutting, depth 3·9 feet at the top of the mixed silting. (There is no doubt about the finding of the brooch in this position, as it was discovered by the writer.)

163. Six small fragments of coarse, hand-made, badly baked prehistoric pottery, ornamented on the external surface by lines of twisted cord pattern and finger-nail marks. Also a straight rim fragment, of similar character, ornamented externally by four parallel lines of twisted cord pattern, and internally by a single row of the same, below which there is a row of deep finger-nail marks. Depth 5·8 feet near the bottom of the mixed silting.

164. Straight piece of red-deer antler, apparently unworked; length 6⅛ inches. Depth eight feet in the middle of the fosse near the bottom of the mixed silting.

165. Greater part of a large rib-bone, probably of ox, with rough, slightly incised, longitudinal scoring. Found resting on the floor of the fosse.

166. Hollow-scraper, or arrow-shafter, of flint. Depth 4·6 feet in the mixed silting.

167. A large number of fragments of hand-made prehistoric pottery, the largest piece, after repair, measuring about 2½ by 2¾ inches; maximum thickness, ½ inch. The fragments were distributed over 2 or 3 feet of ground in burnt material, and seeing the importance of the 'find' after the first piece or two had been collected, the writer obtained a sieve through which all the surrounding material was passed. This pottery has not yet been microscopically examined, but the ware is coarse internally, the surfaces being carefully finished to receive impressed ornament; black on the inner surface, a light reddish-brown on the outside. At about 43 mm. below the almost straight rim there is a decided shoulder or ridge encircling the vessel with a hollow moulding below it. The ornamentation between the top of the rim and the shoulder consists of a double row of herring-bone pattern impressed before baking by means of a notched implement of wood, bone, or antler, or perhaps by a piece of shell having natural ribbing. Below the shoulder there is similar ornament, but owing to the fragmentary state of the portion of the vessel remaining it is impossible to say how far this style of decoration extended in the direction of the bottom of the pot. With the pottery were found three flint flakes (one with secondary chipping), pieces of burnt iron pyrites and very small bits of burnt bone. Found in the mixed silting, depth five feet in the western half of the cutting.

168. Small piece of coarse hand-made prehistoric pottery, containing grains of quartz; described as of the Bronze Age *type* in the former reports. Depth 14 feet in the chalk rubble.

169. Part of a human *humerus*, and the greater portion of a human *tibia* (both from the left side of the body). The *tibia* is of small size

and the following measurements can be obtained: Antero-posterior diameter 30 mm., transverse diameter of the shaft 21 mm., latitudinal index 700. Depth 4·5 feet in the mixed silting.

170. Complete shed antler of red-deer, of medium size, the brow- and bez-tines broken off; total length in a direct line 22 inches. There is no evidence of its having been used as an implement. Found on the floor of the fosse near the south margin.

171. Rib-bone of an animal (smaller than ox), cut to a rounded termination at one end, where it is very smooth and slightly bevelled from one side. Found on the floor of the eastern half of the fosse, against the north face.

172. Crown of an antler of red-deer, with three points or surroyals, which bear evidence of some wear, and may have been used as a rake. Found on the bottom of the fosse near No. 171.

173. Fragment of the base of an antler of roe-deer. Depth five feet in the mixed silting.

174. Small antler of a very young red-deer. Depth 5·5 feet in the mixed silting.

175. Broken pick of shed red-deer antler; the bez- and trez-tines removed, the brow-tine broken; evidence of hammering is seen on the back of the burr. Depth 14·8 feet in the chalk rubble, near the floor and close to the western margin of the cutting.

176. Broken pick formed from a shed antler of a large red-deer; maximum circumference of the beam between the two lower tines, 161 mm.; the brow-tine has its point missing; considerable evidence of hammering is seen on the back of the burr. Also part of a rib-bone, probably of ox. Found on the bottom of the fosse on the west margin of the cutting.

A few other fragmentary animal bones were found on the bottom of the fosse, among which pig was identified.

Flint flakes were perhaps not quite so numerous as in Cuttings I. and II. (1908-09).

Some of the wood specimens, animal remains, and shells have not yet been examined.

V. *General Remarks on the Relics discovered.*

In the last chapter it is shown that no fragment of mediæval pottery was found at a greater depth than three feet, and that all were situated well within the deposit called 'surface silting.' The objects and pottery of the Roman period were all found between the depths of 3·5 feet and 4·5 feet in the upper part of the 'mixed silting.' In the lower part of that deposit the flint knife, No. 154, was found at a depth of 5·7 feet, the hollow scraper of flint, No. 166,[1] depth 4·6 feet, and the prehistoric pottery, Nos. 163 and 167, already described, depth 5·8 feet and 5 feet respectively. It is seen, then, that the lowest object of the Roman period and the highest pieces of prehistoric pottery were in relative levels, only six inches apart. Passing to the 'fine mixed

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[1] This may, perhaps, belong to the 'fine mixed silting' deposit at its highest level.

silting,' nothing was obtained but unworked pieces of red-deer and roe-deer antler. In the lowest deposit, the 'chalk rubble,' a small fragment of prehistoric pottery was found at a depth of 14 feet, a broken antler pick[6] at a depth of 14·8 feet, another on the bottom, a worked rib-bone also on the floor, and a complete red-deer antler and the crown of another in the same position. This season we found no traces of worn animals' *scapulæ* on the bottom of the fosse, but in 1909 we obtained convincing proof that these bones were, with slight alteration, used as shovels for removing loose chalk.

There are no special remarks to be made on the mediæval or Roman pottery shards. The small cleat is an object of frequent occurrence in Romano-British deposits, and its use as portion of the iron furniture of sandals, or shoe leather, is proved by the discovery of specimens, with a quantity of hobnails, at the feet of skeletons at Rotherley and Bokerly Dyke.[7] A specimen was found on the old surface line under the rampart of the Wansdyke, a few miles south of Avebury.[7]

The Roman brooch, or fibula, No. 162, already described as bearing the maker's name, AVCISSA, is a personal ornament of very definite type and date (first half the first century, A.D.); and it adds one specimen more to the short list of brooches bearing this inscription found in England. A similar fibula with the same lettering was found in the parish of Marlborough last year, and is here placed on record for the first time; it may be seen in the collection of Mr. J. W. Brooke of that town. Recently the writer recorded and figured a similar brooch (with the S's reversed) found on Ham Hill, South Somerset.[8] Two other examples come from the same county and were found about 1875 in the Roman lead-workings at Charterhouse-on-Mendip (Bristol Museum).[9] Two others were found at Cirencester (one is in the Bathurst Museum, the other in the Cripps Museum).[10] A large collection of Roman remains bought for Hull Museum in 1905 included two 'Aucissa' fibulæ, found presumably in a Roman cemetery at South Ferriby, Lincolnshire.[11] Professor F. Haverfield had up to 1905 recorded twenty-eight fibulæ bearing this name, of which six were then known from England; the Ham Hill, Marlborough, and Avebury examples have now been added to the list. The type, without inscription, is not rare, and has been found commonly in many parts of the Roman Empire north of the Mediterranean, and outside it, including the Caucasus and Tomsk in Siberia.

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[6] It will be unnecessary to write at any length on the picks of 1911, as those found in 1908 and 1909 were finer specimens, and were fully described in the former *Reports*. The antler picks found in 1908–10 at Maumbury Rings have also been recorded (*Proc. Dor. Field Club*, xxix., 256–272 ; xxx., 217–235 ; and xxxi., 230–266). For general particulars on this subject see Mr. H. W. Sandars' recent paper 'On the Use of the Deer-Horn Pick in the Mining Operations of the Ancients,' *Archæologia*, lxii., 101–124.

[7] 'Excavations in Cranborne Chase,' ii., 190 ; iii., 102, 106, 129, 270, &c. Last year two cleats were found at Maumbury Rings. (*Proc. Dor. Field Club*, xxxi., 245.)

[8] *Proc. Som. Arch. Soc.*, lvi., ii., plate facing p. 55, fig. 10, A and B. Mentioned also in *Proc. Soc. Antiq. Lond.*, xxi., 131, with others.

[9] Figured in *Archæol. Journ.*, lx., plate facing p. 240 ; and *Vict. Co. Hist. Somerset*, i., 343.

[10] *Archæol. Journ.*, lxii., 265.

[11] *Ibid.*, lxii., 265–6.

The finely chipped flint knife, No. 154, already described, has every appearance of great age, and is of typical Neolithic form. It is similar in shape to the knife found by Canon Greenwell in a barrow on Wykeham Moor, Yorkshire, but smaller.[12]

Perhaps the most important discovery made this season is that of prehistoric pottery, Nos. 163 and 167 (previously described in detail), found at depths of only 5·8 feet and 5 feet respectively below the surface of the silting. The presence of ornament of a definite type renders them the easier of identification. Sufficient remains of the rim and sides of No. 167 to identify the typical 'shoulder,' with hollow moulding below it, but unfortunately there are no fragments of bottom, and therefore it is impossible to say whether the vessels had round or flat bases. The upper part of the vessels may be described as having straight rims with a slight bevelling of the lips on both sides. The rim piece, No. 163, with twisted cord pattern on the external surface, can be matched exactly by a fragment of pottery (not figured) found in the West Kennet Long-barrow, and now in the British Museum.

The pattern on the several fragments comprising No. 167 has already been described, and it only remains to say here that the ornamentation is of the same kind as that which embellishes the well-known pieces of pottery found in the Long-barrow at West Kennet, near Avebury, of which a few fragments may be seen in the British Museum, and a larger series in Devizes Museum. One of these fragments with the grooved herring-bone design, the depressions being ornamented by transverse notches, has frequently been figured as a specimen of Stone Age pottery.[13]

Ornament precisely similar to that on the Avebury fragments (No. 167) is seen on the Neolithic bowls from Peterborough and the Thames at Mortlake (but the ribbing across the grooves is not clear in the latter specimen).[14] Similar decoration is also seen on a fragment of prehistoric pottery found in association with Roman remains only 1·1 foot deep in the silting of the ditch of Wor Barrow (long-barrow), Handley, Dorset. Its position in the ditch was of no datable value, and the fragment must have been mixed with the soil when deposited in the position in which it was found.[15] Two round barrows near Handley (Barrow 24 [16] and Barrow 29 [17]) also produced prehistoric pottery bearing the same type of ornament as these Avebury shards. That in the first barrow was found at a depth of a foot on the chalk floor; the mound was small, with encircling ditch, outside which no fewer than fifty-two cremated interments were discovered. That in the second was found in the body of the mound, depth 1·8 foot. These fragments were probably in the soil originally thrown up to form the barrows, and as Neolithic man is known to have used Handley Downs for

[12] Evans' 'Stone Implements,' first ed., p. 297, fig. 242; *Archæol. Journ.*, xxii., 243.

[13] *Archæologia*, xxxviii., 405, fig. 15; lxii., 343, bottom right-hand fig.; Lord Avebury's *Prehistoric Times*, sixth ed., p. 152, fig. 160; *Stone Age Guide*, Brit. Mus., 1902, p. 114, fig. 139.

[14] *Archæologia*, lxii., 336, fig. 3, and plate xxxvii., fig. 3.

[15] *Excavations in Cranborne Chase*, iv., plate 261, fig. 17.

[16] *Ibid.*, plate 298, fig. 8; see remarks also on pp. 147, 163.

[17] *Ibid.*, plate 304, fig. 7.

funereal purposes, there was every likelihood of Neolithic shards becoming scattered in the neighbourhood. This is mentioned because General Pitt-Rivers says in regard to this ware that, in spite of the West Kennet pottery being assumed to be of the Stone Age, the fragments from Handley bearing similar decoration were without doubt associated with relics of the Bronze Age. He inclined to the conclusion, therefore, that the pottery in question was referable to the Bronze Age.

But the study of prehistoric pottery has developed considerably even since the General's time, and although the *gisement* of shards of ancient pottery (upon which one's conclusions are partly based) is of the highest importance in archaeological excavations, single pottery fragments of earlier date, in a locality successively occupied by tribes from and including the Stone Age, must occasionally have become mixed with relics of later times, and especially in localities frequented by burrowing animals.

The writer is inclined on the whole to regard these pottery fragments, Nos. 163 and 167, as being of Neolithic date, and it is possible that some of the unornamented fragments described as being of Bronze Age *type* in the former reports may really belong to the Stone Age. At the same time it should be pointed out that no pottery of the drinking-vessel, or beaker, type has yet been discovered at Avebury; and it should also be repeated that only 6 inches of silting divided the lowest object of Roman date found from the prehistoric pottery discovered nearest the surface.

A small fragment of pottery belonging to No. 163 was sent to Mr. Clement Reid for close examination, and he has kindly sent the following interesting report:—

'The "grout," or coarse material used for stiffening this pottery and making it keep its shape when burnt in an open fire, is of unusual composition. It consists mainly of fragments of burnt bone, with a few minute bits of charcoal. I think that ashes of a fire have been used, as being grit that would not fly, shrink, or burn out when the pottery was fired; there are also one or two small fragments of flint. The clay with which this "grout" was mixed seems to have been a coarse sandy clay with large rounded grains of quartz. Probably the so-called "clay-with-flints" so common on the chalk-downs was used. As far as one can judge from so small a sample, only enough clay was used to bind the material.'

VI. *Concluding Remarks.*

From the detailed description of the relics discovered in Cutting VIII., and on reference to the former reports it will be seen that the objects found this year are more important with regard to the much debated subject, 'the date of Avebury,' than those discovered previously. The strong negative evidence of date afforded by the absence of metals below the Roman stratum of silting has now been greatly strengthened by the discovery of prehistoric pottery of a well-known

kind—a type which has been associated with Long-barrows and such early settlements as the prehistoric pits at Peterborough.[18]

All the objects discovered in the lower half of the mixed silting, in the fine mixed silting, and in the chalk rubble, are such as are characteristic of the Neolithic period, and we have decidedly less hesitation in regarding the fosse of Avebury as being of Neolithic construction than we had at the close of the excavations of 1909. The relics discovered have not been numerous, but considering the early date and the great extent of Avebury, and the comparatively small area yet excavated, the most optimistic antiquary could hardly have expected to find a greater variety of objects in the prehistoric area than pottery with characteristic ornament; flint knives and scrapers, and flakes with secondary chipping; picks, hammers, levers, and other implements of antler; bone shovels, and other bones more or less worked.

We have proved much, but have yet a good deal to learn with regard to the mode of construction of Avebury and the methods adopted in excavating the stupendous fosse and raising the great vallum.

It will be a great disappointment if a means cannot be found to make an adequate examination of the southern entrance-causeway of Avebury and the items of structural interest adjoining it, and a serious hindrance to archæological research and to the endeavour to piece together the history of Britain's greatest prehistoric stone monument.

VII. *Grants and Subscriptions.*

In addition to the grant of 30*l.* made by the British Association for the excavations of 1911, the following private donations and grants were kindly subscribed to the fund:—

	£	s.	d.
The Hon. John Abercromby, F.S.A. Scot.	15	0	0
Society of Antiquaries of London	5	0	0
The Lord Avebury, D.C.L., F.R.S.	5	0	0
Marlborough College Natural History Society	5	0	0
The late N. Story Maskelyne, F.R.S.	3	3	0
C. H. Read, LL.D., P.S.A.	2	2	0
Henry Balfour	2	2	0
W. M. Tapp, LL.D., F.S.A.	1	1	0
Horace Sandars, F.S.A.	1	1	0
Albany F. Major		10	6
T. H. M. Bailward		10	0

And the following donations from members of the Wiltshire Archæological and Natural History Society (*per* the Rev. E. H. Goddard):—

	£	s.	d.
The Marquess of Lansdowne	5	0	0
Lord Edmond Fitzmaurice	5	0	0
W. Heward Bell, F.S.A.	2	2	0
Sir Prior Goldney, Bart., C.V.O., C.B.	2	0	0
F. H. Goldney	1	1	0
A. W. H. Burder, F.S.A.	1	1	0
Captain Jenner		10	6
J. E. Ward		10	0

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[18] *Archæologia*, lxii., 333, *et seq.*

Hausa Folklore.—Report of the Committee, consisting of Mr. E. S. Hartland (*Chairman*), Dr. A. C. Haddon (*Secretary*), *and* Professor J. L. Myres, *appointed to advise on the best method of publishing a collection of Hausa Folklore with translations and grammatical notes.*

The Committee report that they have approached various publishing institutions, but have not been able to induce any of them to undertake the publication of the collection of Hausa Folk-tales with translations and grammatical notes. The Under Secretary of State for the Colonies was memorialised on the subject, but as arrangements were already in contemplation for subsidising a similar work by another officer, Mr. Harcourt regretted that he was unable to see his way to recommend a second work of the same nature for Government assistance. The Committee do not seek reappointment.

The Dissociation of Oxy-Hæmoglobin at High Altitudes.—Report of the Committee, consisting of Professor E. H. Starling (*Chairman*). J. Barcroft (*Secretary*), *and* W. B. Hardy.

Mr. Ff. Roberts collaborated with Dr. G. C. Matheson on the expedition to Pisa (sea-level) Col d'Olen (10,000 feet), and Capanna Margherita (15,000 feet). They determined the hydrogen-ion concentration of the blood (exclusive of that induced by CO_2) by a new method as follows: The addition of acid to the blood decreases the affinity of the hæmoglobin for oxygen. This was first shown by Bohr, who used CO_2. Carbonic acid is not, however, specific. At a standard oxygen tension, therefore (15 mm. $O_2$0 mm. CO_2 at 37° C.), the greater the amount of acid in the blood the less the degree of saturation with oxygen. A scale was made out at Pisa for the blood of each member of the party, and successive given quantities of lactic acid were added to the blood, and the degree of saturation with oxygen was noted in each case. When the scale had once been made it became possible to estimate the abnormal acid present in the blood at higher altitudes, by observing the percentage saturation under standard conditions.

All members of the party at Col d'Olen showed an addition of acid which in most cases was equivalent to about 0·025 per cent. lactic acid, and about twice that amount at Capanna Margherita. After exercise, however, the amount of acid present was much greater. Thus, immediately on arrival at Col d'Olen, after walking from Alagnia Sesia, an ascent of from 7,000 to 8,000 feet, Mr. Roberts' blood contained excess of acid equivalent to 0·08 per cent. lactic acid, and on arrival at Capanna Margherita, after a nine days' stay at Col d'Olen, 0·7 per cent. An interesting point about the addition of acid is that it is not immediately excreted on descent from a high altitude. This facts leads to a lower CO_2 tension in the alveolar air at Col d'Olen after descent from the Capanna Margherita than before the ascent; and in order that the respiratory protient might be maintained,

there was a correspondingly higher oxygen tension—a striking demonstration of the advantage, at a given altitude, of making an ascent and returning.

Anæsthetics—Third Interim Report of the Committee, consisting of Dr. A. D. WALLER (*Chairman*), Sir FREDERIC HEWITT (*Secretary*), Dr. BLUMFELD, Mr. J. A. GARDNER, *and* Dr. G. A. BUCKMASTER, *appointed to acquire further knowledge, Clinical and Experimental, concerning Anæsthetics—especially Chloroform, Ether, and Alcohol—with special reference to Deaths by or during Anæsthesia, and their possible diminution.*

General Report.

THE Committee have held five meetings during the past year; their attention has been principally directed to the clinical application of the laboratory results of the previous year (*vide* Second Interim Report of the Committee to the British Association for the Advancement of Science, p. 268, Sheffield, 1910, and First Interim Report, p. 303, Winnipeg, 1909), more especially as regards (1) the administration of ether, and (2) the clinical application of the chloroform balance.

(1) The principles upon which the practice of ether administration should be based—entered upon in our report of last year—have formed a principal subject of our study during the past year. Our anticipation that a 10 per 100 mixture of ether-and-air, found to be adequate for the continuous anæthesia of animals in the laboratory, would also be found adequate for the production and maintenance of surgical anæsthesia in man, have so far been confirmed that it appears (Appendix II.) that in the method of administration termed 'open ether' the percentage of ether delivery is approximately 10 per 100.

(2) Acting on behalf of this Committee, Sir Frederic Hewitt early in the year approached the Medical Committee of St. George's Hospital with a view to the installation at that institution of a chloroform-balance for the routine purposes of anæsthesia, and explained that the purpose of this installation was to further the safe anæsthetisation of patients by the application to them of a method of which the safety had been ascertained by experiments upon animals in the laboratory (Appendix II. of the First Interim Report and Appendix I. of the present report).

A chloroform-balance was accordingly installed in the out-patient theatre of St. George's Hospital, where it has been in regular use for

the past six months, principally in the hands of Mr. G. R. Phillips, the resident anæsthetist, whose report is contained in Appendix III., and under the frequent observation of Sir Frederic Hewitt, Dr. Blumfeld, and Dr. Waller.

This Committee desire to tender their sincere thanks to the House Committee of St. George's Hospital for their liberal co-operation.

In the laboratory our knowledge has been augmented by the independent work of Dr. Buckmaster and Mr. Gardner, who have throughout the year accumulated a large mass of valuable data concerning the composition of the blood-gases in chloroform anæsthesia in the physiological laboratory of the University of London. Their full paper has been published in the 'Journal of Physiology' of March 1911.

A further paper on *the ventilation of the lung during chloroform-narcosis*, of which the account must be deferred, has been communicated to the Royal Society during the present month [November 1911].

APPENDIX I.

The Installation of a Chloroform-balance in Hospital for Ordinary Daily Use. *By* A. D. Waller, *M.D., F.R.S.*

The principle upon which the apparatus is based has been described in several publications, most fully so in the fifth Hitchcock Lecture published last year.[1] It will be sufficient in preface to the present description of the apparatus as set up for practical purposes at St. George's Hospital to state that the object to be fulfilled is the delivery at a face-piece of a sufficient volume of chloroform-and-air of known and easily controlled percentage.

The essential parts of the apparatus are:—

1. The chloroform-balance,
2. The chloroform flask,
3. A mechanical blower, and
4. Tubing from the blower to the flask and balance, and from the balance to the face-piece or mask.

Graduation of the Chloroform Balance.

The *chloroform-balance* consists of an ordinary enclosed balance with the scale-pans replaced by a closed-glass bulb of a capacity between 500 and 1,000 c.c. and a brass counterpoise. The bulb rises and falls according as the density of atmosphere in the balance-case is raised and lowered by chloroform vapour driven into the case from the chloroform flask. The sensitiveness and range of movement of the beam are such that the deflections of the index embrace a range of at least 3 per cent. of chloroform-vapour present. The graduation of the scale behind the index is determined by the weight of chloroform-vapour per 100 in relation to the capacity of bulb used, taking the litre-weight difference between chloroform-vapour and air = 4·045 grammes at 0° and 760 mm. Hg. Thus for a bulb of 1,000 c.c. the weights corresponding to 1, 2, and 3 per cent. are 38, 76, and 114

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[1] *Physiology the Servant of Medicine: Chloroform in the Laboratory and in the Hospital.* The University of London Press, 1910.

milligrammes. The weights to be used for the graduation of bulbs of 500 to 1,000 c.c. are given in the following table:—

Capacity of Bulb	Weights in Milligrammes, indicating 1, 2, and 3 per cent. $CHCl_3$ at 18° and 760 mm. Hg.		
	1 per 100	2 per 100	3 per 100
c.c.			
264	10·00	20·00	30·00
500	18·98	37·95	56·93
525	19·93	39·86	59·79
527	20·00	40·00	60·00
550	20·87	41·74	62·61
575	21·82	43·64	65·46
600	22·72	45·44	68·16
625	23·72	47·44	71·16
650	24·67	49·34	74·01
654	25·00	50·00	75·00
675	25·62	51·24	76·86
700	26·58	53·16	79·74
725	27·51	55·02	82·53
750	28·46	56·92	85·38
775	29·41	58·82	88·23
790	30·00	60·00	90·00
800	30·36	60·72	91·08
825	31·31	62·62	93·93
850	32·25	64·50	96·75
875	33·21	66·42	99·63
900	34·15	68·30	102·45
922	35·00	70·00	105·00
925	35·10	70·20	105·30
950	36·04	72·08	108·12
975	37·00	74·00	111·00
1000	37·95	75·90	113·85
1054	40·00	80·00	120·00
1186	45·00	90·00	135·00
1308	50·00	100·00	150·00

The *sensitiveness* of the balance and the range of movement of its beam between the stops should be such as to afford a maximum range of 5 per 100. By adjustment of the counterpoise the zero of the scale is taken with the lever to the left of the vertical position by an amount effected by a weight = 1·5 per 100 (*i.e.*, by a weight of 30 milligrammes in the case of a 525 c.c. bulb). From this zero position the positions corresponding to 1, 2, and 3 per cent. are marked as the index is deflected with the 5 per cent. rider at 1, 2, 3, on the left side of the beam. Graduated in this way the balance is adapted to direct reading up to a maximum of 3 per 100; the scale is relatively contracted, and fine readings are not to be expected; the unit can at best be divided into four quarters. This relatively insensitive form of balance can be used as a recording instrument (*vide infra*) and corrections for variations of temperature and pressure during observation are negligible. It may be referred to as type A.

Graduation by a 5 per 100 rider.—With the beam of the balance divided into ten parts, the counterpoise corresponding to 1, 2, and 3 per cent. are most expeditiously secured by a rider of which the weight corresponds to 5 per cent. of chloroform in relation to the capacity

of the bulb. Thus with a bulb = 527 c.c. a decigramme rider (100 milligrammes) placed at the 1, 2, 3, 4, 5, on the same side as the bulb, will counterpoise the ascensional force of air (at 760 mm. and 18°) containing 1, 2, 3, 4, 5 per cent. of chloroform vapour. The same counterpoise placed at 1, 2, 3, 4, 5, on the opposite side of the beam, will raise the bulb (in air) and give deflections of the index corresponding to 1, 2, 3, 4, 5 per cent. of chloroform vapour.

Thus by placing the rider at 1, 2, 3 on the left-hand side, the deflections of index corresponding to 1, 2, and 3 per cent. of chloroform are readily determined.

Finer readings—one-tenth per cent. and less—can be made by means of a more sensitive instrument and a larger bulb, using a null method, the first or coarse adjustment being effected by a rider. The 5 per 100 rider alluded to above is suitable to this purpose.

With a balance giving a swing of 2·5 mm. per milligramme, and a bulb of 1,054 c.c. capacity, we have 1 per cent. = 40 milligrammes, so that the 5 per cent. rider is to be taken = 200 milligrammes; 2·5 mm. swing = 1 milligramme = 1/40 = 0·025 per cent., so that 1 mm. swing = 0·01 per cent. Thus on such an instrument we have each

		Per cent.
Large division of beam	=	1·00
Small division of beam	=	0·10
Millimetre of swing	=	0·01

With a bulb of 527 c.c. capacity the 5 per cent. rider must be taken = 100 milligrammes. In this case 1 mm. of swing indicates 0·02 per cent.

With this more sensitive balance—that may be designated as type B—it is possible to observe with great exactness the percentage of delivery. Thus, *e.g.*, with the rider at 2·1 and the index at 0, the percentage is 2·10. With the rider as before and the index swinging 10 left-5 right, the percentage is 2·05. With the index swinging 5 left-10 right the percentage is 2·15. With the index swinging 5 left-2·5 right the percentage is 2·075.

For ordinary hospital use type B is inconveniently and unnecessarily sensitive; the readings to be of any accuracy must be corrected for temperature and pressure. Moreover the system cannot be left swinging while a current of chloroform-and-air is passing through the balance-case. The beam must be out of action while the current is passing, and the current must be interrupted while an observation of density is taken. Nevertheless, for purposes of exact study as, *e.g.*, where it may be desired to know how closely a given percentage has been observed, type B may occasionally be of service, but in such cases it should be used in series with an instrument of type A, with a two-way tap and short-circuiting tube, so that the delivery to the patient is not interrupted while the current through balance B is turned off.

The corrections for temperature and pressure are made according to the formula:—

$$\log P = 1{\cdot}8377 + \underset{\substack{\text{weight of}\\ \text{counterpoise}\\ \text{in mgrms.}}}{\log m} - \underset{\substack{\text{volume of}\\ \text{bulb in}\\ \text{c.c.}}}{\log v} + \underset{\substack{\text{absolute}\\ \text{temp.}\\ \text{(centigr.)}}}{\log T} - \underset{\substack{\text{pressure}\\ \text{in mm. Hg.}}}{\log B}$$

e.g., given a reading of 2·15 per cent. at 20° and 770 mm. Hg, what is the percentage?

2·15 per cent. = 86 milligrammes.

$$\log P = 1{\cdot}8377 + \log 86 - \log 1054 + \log 293 - \log 770$$

$$\begin{array}{lll}
 & 1{\cdot}9345 & 3{\cdot}0228 \\
\text{add} & 2{\cdot}4669 & 2{\cdot}8865 \\
\cline{2-3}
 & 6{\cdot}2391 & 5{\cdot}9093 \\
\text{subtr.} & 5{\cdot}9093 & \\
\cline{2-2}
 & 0{\cdot}3298 &
\end{array}$$

$P = 2{\cdot}137$, instead of $2{\cdot}150$.

The correction is $-0{\cdot}013$.

Take an extreme case of a balance used at St. Moritz at temperature = 20° and pressure = 650 mm. Hg. Reading as before = 2·15

$$\log P = 1{\cdot}8377 + \log 86 - \log 1054\ 2 - \text{or} + \log 293 - \log 650$$

$$\begin{array}{ll}
1{\cdot}9345 & 3{\cdot}0228 \\
2{\cdot}4669 & 2{\cdot}8129 \\
\hline
6{\cdot}2391 & 5{\cdot}8357 \\
5{\cdot}8357 & \\
\cline{1-1}
0{\cdot}4034 &
\end{array}$$

$P = 2{\cdot}531$, instead of $2{\cdot}15$.

The correction is $+0{\cdot}381$.

Adjustment of the Scale to the Index.—With a chloroform-balance of type A there is, as stated above, no need to take account of variations of temperature and pressure during administration. The position of the index in front of the scale (or if the instrument is used as a recorder the position of the pen against the recording surface), with only air in the balance-case is the zero or point of departure for measurement (or record) of the percentage of chloroform vapour subsequently present. The position of that zero will be found to vary slightly on different days by reason of differences of temperature and pressure; as regards the record, if such be taken, this variation of position of the zero line is of no account, but if we are taking for our guide the position of the indicator in front of a fixed scale it is inconvenient to have a zero that does not coincide with the zero marked on the scale. The discrepancy, if considerable, can be corrected by alteration of the counterpoise, but it is more convenient to slide the scale slightly to the right or left by means of a screw adjustment until its zero coincides with the zero position of the index.

Readings of the scale are best taken with the beam of the balance and the indicator oscillating freely right and left of a middle point, which is the actual reading. The oscillations can be damped so that readings are taken with the indicator at rest by means of a light bristle fixed to the indicator and rubbing lightly against the glass surface of the scale. But if this device is employed it must be verified as not liable to cause the indicator to stick in consequence of excessive friction so as to give false readings.

When a record of the administration is taken—a proceeding which I do not recommend for the ordinary use of the apparatus—a satisfactory damping of oscillations is afforded by the point of contact of the

recording pen with the recording surface. The latter is adjustable to the former by means of a fine-pitched screw. The pen itself is filled with a special non-drying ink, so that the actual contact between pen and paper is formed by the ink itself. But the adjustment is a delicate one that requires attention, and I do not like to be troubled with it in the hospital use of the balance.

At the bulb-volume 546 c.c. the bulb *sinks* with a rise of temperature of 1° by reason of a diminution of ascensional force equal to the weight of $\frac{546}{272}$ or 2 c.c. of air, *i.e.*, 2·6 milligrammes approximately, and the index is displaced to the left. Similarly the bulb *rises* and the index travels to the right with fall of temperature.

Variations of pressure have a reverse effect. With a bulb of, say, 532 c.c. and a rise of pressure from 760 to 770 mm. Hg., the ascensional force affecting the bulb is increased by an amount equal to the weight of $\frac{532}{760}$ or 7 c.c. of air, *i.e.*, 9 milligrammes approximately.

Obviously the zero or point of departure of the index may wander sensibly above or below the zero of a fixed scale. Thus a rise of 2° with a fall of 10 mm. in relation to a 527 c.c. bulb gives approximately − 5 and − 9 milligrammes. At this capacity the weight value of 1 per cent. chloroform is 20 milligrammes, so that the position of the index under these conditions will be shifted to a position 14/20 or 0·7 to the left of a fixed zero. Obviously, however, the readiest means of correcting for this wandering is to slide the scale to the left until its zero corresponds to the position of the index.

The Chloroform Vessel.

The vessel containing liquid chloroform over which the current of air passes into the balance-case is double, consisting of two identical vessels each provided with a two-way tap, allowing the current of air to pass (*a*) directly or (*b*) over the surface of the liquid chloroform. With a tap at 'off' the air passes directly, and no chloroform vapour enters the case. With a tap at 'on' air passes over the chloroform, and enters the case more or less charged with chloroform vapour. The two vessels are in series, so that the current of air can be directed through one or other or both the vessels.

Under ordinary circumstances, *i.e.*, with a balance-case of a capacity of 30 litres and an air current of, say, 10 litres per minute passed through only one chloroform vessel, *i.e.*, with its tap turned 'on,' the percentage of chloroform vapour in the case, as shown by the rising bulb, rises gradually but sufficiently rapidly to a maximum value from which it subsequently and slowly declines to a minimum value, at which it remains for an indefinite time. The initial rising percentage is the natural effect of the current of chloroform-laden air at 10 litres per minute pouring into the air-filled reservoir of 30 litres capacity. This rise is such that at the end of the first minute the atmosphere in the case is at about 1 per cent. chloroform, and in the third minute at about 2 per cent. The maximum value is between 2 and 3 per cent. The subsequent steady minimal value is at about 1·5 per cent. This natural

rise and fall of percentage is in my opinion well-adapted to the ordinary requirements for the induction and maintenance of anæsthesia. The gradual rise to 1 and 2 per cent. during the first two or three minutes is precisely what is required at the outset of administration. The rise to 2·5 per cent. is not excessive, and is corrected by the use of an open mask or by an occasional removal of the mask. The subsequent slow fall to 1·5 is what is usually required in the maintenance of anæsthesia after the period of induction.

The Conditions of Ordinary Administration are thus naturally favourable and simple. With a normal current of air of 10 litres per minute delivered by a rotary pump (*vide infra*) through a single chloroform-vessel, the percentage of chloroform delivered at the mask is approximately what is most suitable throughout an administration of chloroform. The sole manipulation required consists in the turning 'on' of one tap; the mask is, as a general rule, given to the patient to hold, at least for the first minute or two, and as a rule this helps to secure confidence. Later, of course, or with a young or refractory patient, the mask must be held on by the administrator.

The main object of a chloroform-balance is to secure the uniform delivery of chloroform-and-air in sufficient volume and at suitable strength. The considerable capacity of the balance-case affords a reservoir of mixture that prevents the occurrence of sudden variations of percentage and acts in the sense of a flywheel. By means of the tap the percentage of chloroform can be readily raised or lowered. By turning on the second tap the percentage can at once be raised if the steady current through one bottle only gives a mixture that requires to be enriched, and this augmentation of percentage can be effected quite as rapidly as may be desirable. But the apparatus is not adapted to sudden lowering of percentage for the purpose of immediately reducing an amount of chloroform that may be judged to be greater than necessary. Such reduction should, of course, be started at once by the obvious means at hand, *i.e.*, by removal of the mask.

The blood and tissues of an anæsthetised patient are in a reservoir filled to a certain degree or tension by the chloroform that has been inspired and absorbed, and evidently the first thing to be done when the symptoms indicate that there is more than enough chloroform in the body is to stop the supply altogether.

At a time when my chief preoccupation was to influence the discussion of the chloroform question in the direction of numerical measurement I stated that safe administration consists in the continuous administration of chloroform vapour and air between the limits of 1 and 2 per 100. I made this statement well knowing that in many cases 2 per cent. may and must be exceeded, at least nominally, but in the belief that it was preferable to name a low rather than a high maximal value. Whatever limit was named it was certain to be exceeded, and I felt it preferable that a higher limit should be recognised as permissible in consequence of the experience of independent observers than that it should be stated from the outset. At the present time I am willing to admit that the normal upper limit of 2 per 100 may and must frequently be exceeded, because in administration by a mask the real

percentage of mixture inspired is lower than its nominal percentage as delivered through the balance. The chief cause of the difference between the real and the nominal percentages arises from the mask.

The *mask* should be as far as possible continuously applied. I do not think it necessary that it should fit hermetically to the face. But in order to secure its uniformity of leakage it is advisable to provide it with an orifice of exit providing for uniform overflow of the chloroform mixture. Under these conditions it is clear that the percentage inspired must be below the percentage delivered. The precise amount of this deficit it is difficult to estimate with any degree of accuracy. It obviously must vary with the rate of supply and the rate and depth of respiration. Given, *e.g.*, a supply of 12 litres per minute or 200 c.c. per second, respiration at 400 c.c. twenty times per minute with inspiration and expiration lasting each for 1½ second, it is evident that in an inspiration during 1½ second of 400 c.c. from an open mask into which only 300 c.c. are pumped, there must be a surplus of 100 c.c. inspired directly from the atmosphere. The patient then inspires 300 c.c. of 2 per 100 mixture *plus* 100 c.c. of air, *i.e.*, 400 c.c. of 1·5 per 100 mixture. Under these conditions the percentage of delivery must be 2⅔ per 100 if the percentage inspired is to be 2 per 100.

A very brief experience of the balance as used with an open mask teaches the percentage values required in different cases and for various requirements. The depth of anæsthesia can be increased or diminished by driving the apparatus at a higher or lower percentage number.

By the use of an inspiratory and expiratory valve and an elastic bag the percentage actually inspired is made as nearly as possible equal to the percentage indicated. The use of a closed mask, while it is essential for the study of the real as distinguished from the nominal percentages required in varying degrees of anæsthesia, is not practically necessary for the actual induction and maintenance of anæsthesia for hospital purposes. My own opinion is in favour of the use of an open mask for hospital purposes. The fact that the indicated is above the actually breathed percentage is a matter of secondary importance as compared with the simplicity and convenience afforded by the continuous delivery at the mask of an adequate mixture. In this method, as in every other, due attention must be paid to the state of the patient, and I readily admit that for the exact study of minimum necessary percentage continuously inhaled, a closed mask with inlet and outlet valves is indispensable. But at the present my sole concern is to render the chloroform-balance practically available for hospital use, and by so doing to afford further confirmation of my conviction that the effects of chloroform are in direct relation with the concentration at which its vapour is administered, and that a first cause of fatal accidents associated with the use of chloroform must be removed by removing the possibility of the accidental use of the vapour at high concentrations.

Position of the Chloroform Balance.

The tubing (*a*) from the blower to the balance, and (*b*) from the balance to the mask is of ordinary ¾-inch gas-pipe of suitable length. As fixed at St. George's Hospital, the tube from blower to balance is quite short, and passes through the wall from an adjacent room where

the blower is placed. (If necessary, however, this tube might have been of any convenient length. I had previously tested the apparatus to work without loss of efficiency through a length of 50 feet). The delivery tube as fixed in the out-patients' operating room is about 20 feet long from balance to mask, and consists in gas-piping fixed to the wall and ceiling to the centre of the room with flexible tubing joining its two ends to the balance and to the mask respectively. As now set up the balance is placed in the corner of the room where the position of the indicator is not visible to the administrator. This is a serious drawback, and the balance should be moved to a position where the percentage indications can be seen by the administrator. I mention this as a detail of arrangement that was overlooked at first, but which is of sufficient practical importance to require remedy at some sacrifice of the arrangement of the operating room. It leads me to lay stress, for any future installation of a balance, on the advisability of placing the balance against a wall in such a position that the indications can be seen by the administrator. The length and bends of tubes may be made conformable to the position of the balance without appreciable loss of efficiency. In the actual use of the balance it will soon be apparent that with the indicator visible the alterations of percentage made during administration will be much more infrequent than if it is invisible. Practically it is preferable—by reason of the flywheel effect of the large volume of mixture in the balance-case—to work with as little interference with the percentage as possible, and not to meddle with the percentage unless it obviously requires to be altered. As stated above, the percentage resulting from the air delivery through a single chloroform vessel left to itself is very nearly what is required in all ordinary circumstances. It can, of course, be made a little higher or a little lower by manipulation of the taps. It can be promptly raised for a few minutes to three or to four per cent. by turning *on* the tap of the second chloroform vessel. And it can be promptly lowered by turning *off* the tap so as to admit air into the balance-case. But, as stated above, any symptoms indicative of more than enough chloroform are best met at once by removal of the mask.

For ordinary hospital requirements the delivery of the chloroform-and-air through the balance to the mask must be at a low positive pressure and of a volume somewhat in excess of the volume of air required for ordinary respiration.

In testing apparatus in the laboratory before using it in the hospital I have sought to obtain a delivery through the balance of approximately 12 litres of air per minute at a pressure of about one centimetre of water at the distal end of the delivery tube to be connected with an open mask as described.

Transferred to the hospital and in the absence of measuring apparatus, I have become accustomed to verify this delivery roughly by placing the end of the tube in a glass of water, through which the bubbling of air indicated roughly the efficiency of delivery. A water manometer in connection with the interior of the balance-case served the double purpose of showing by the movements of the column of water (1) the efficiency of the mechanical blower, (2) the depth and frequency of the patient's respiration during application of the mask.

The blower was composed of a rotary pump or a fan driven by an electromotor so as to deliver approximately 12 litres of air per minute. An accessory resistance in the circuit of the motor allowed the delivery to be increased or diminished at will within the approximate limits of 10 and 15 litres per minute.

Note.

The chloroform-balance as it stands can be used as an ether-balance, but by reason of the more abundant vaporisation and more rapid cooling, the ether bottles must be surrounded by a warm water-jacket. The chloroform scale, 1, 2, 3 per 100, is practically equivalent to an ether scale, 5, 10, 15 per 100. But, as stated in a previous report, I do not recommend the use of an ether-balance for the routine anæsthesia by ether. As stated in the next appendix, ether is not liable to be given in dangerous amount by any ordinary method. The chief use of an ether-balance has been in the laboratory to obtain knowledge (1) of the relative physiological efficacy of chloroform and of ether vapour at known percentages; and (2) of the actual percentages of ether vapour afforded by an ordinary method, and in particular by what is termed 'open ether.'

APPENDIX II.

On the Percentage of Ether ordinarily afforded by an 'Open' Method of Administration. By A. D. Waller, *M.D., F.R.S.*

Appendix I. of the Second Interim Report to the British Association (Sheffield, 1910, page 270) consists in a preliminary report 'On the Principles of Anæsthesia by Ether Vapour,' and contains the following comparison of the relative efficacy of chloroform and ether as anæsthetics:—

Chloroform is *par excellence* the powerful anæsthetic. It is easy to deliver chloroform-and-air continuously at 1 and 2 per cent. *or more.* And by reason of this facility chloroform anæsthesia, unless great care be observed, is dangerous to life.

Ether is *par excellence* the safe anæsthetic. It is comparatively difficult to deliver ether-and-air continuously at 8 to 16 per 100; and by reason of this difficulty ether anæsthesia is more troublesome, the trouble being to give enough ether.

A fortiori it is difficult to give too much ether, while it is only too easy to give too much chloroform.

It is to be estimated that whereas chloroform-and-air should be maintained at between 1 and 2 per 100, ether-and-air is required at between 8 and 16 per 100.

This estimate of 8 to 16 per cent. for ether was a preliminary figure based on the previous conclusions of the author that for safe anæsthesia by chloroform the percentage must be between 1 and 2, and that the physiological power of chloroform is six to eight times that of ether.[2]

These rough limits of percentage 8 to 16—or more properly 6 to 16—served as a guide for preliminary observations on animals by means of

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[2] Waller, Presidential Address to the Section of Anatomy and Physiology of the British Medical Association, Montreal, September 1897; *British Medical Journal,* November 20, 1897.

an ether-balance, which gave as a preliminary result that full anæsthesia could be produced and maintained by ether-and-air at approximately 10 per 100.[3]

The administration of ether—first employed in 1846 at the Massachusetts General Hospital, Boston, U.S.A.—has ever since continued in use at that hospital to the complete exclusion of chloroform. The method of administration there gradually elaborated, is based on the same principle as that of the method referred to as 'open ether,' *i.e.*, ether is administered from a closed mask kept drenched with ether gradually brought closer to the face until it is quite closely applied so as to give a maximum value of ether concentration in the inspired mixture of ether and air.

The method of 'open ether' has rapidly grown in favour in this country, and this has afforded a reason for ascertaining for ether, by a procedure similar to that followed for chloroform, what are the percentages of delivery under the ordinary clinical conditions of administration.

Mr. Symes, who took a series of densimetric estimations of chloroform delivery seven years ago[4] under definite conditions as closely similar as possible to clinical conditions, has carried out a similar task for ether, using for the purpose a flannel mask applied to an artificial face precisely as practised by Sir F. Hewitt. The observations have been taken with the face and face-piece (1) at the ordinary laboratory temperature of 22° (=71·6° F.), and (2) at a temperature of 37° (=98·7° F.).

In view of the fact that as regards ether administration the danger of giving too *much* hardly exists, the chief difficulty being to give *enough*, the information principally sought for was the value of maximum percentage afforded to the interior of a face-piece freely supplied with liquid ether, and the fall that may be expected to occur in a prolonged administration by reason of evaporation from and cooling of the face-piece.

Observation 1.—Artificial respiration air-pump at twenty-four strokes of 250 c.c., *i.e.*, 6 litres per minute. Densimeter placed on a broad tube (=the trachea) connected with the mouth of an artificial face, over which the mask was placed as for anæsthesia of a subject. In a first trial the tracheal tube was provided with an inspiratory-expiratory valve, so that the expiratory stroke was into the atmosphere and only the inspiratory stroke through the mask, and therefore only suction took place from under the face-piece. Ether was then dropped freely on the flannel. The following scale-readings were taken at two-minute intervals. Room temperature = 22°; barometric pressure = 771 mm. Hg:—

21·4 18 17·6 17

which, corrected by the formula:—

$$\log P = 2{\cdot}1392 + \log m - \log v + \log T - \log B,$$

where the litre-weight difference between ether vapour and air has been taken as 2·020 grams, gives the values:—

22·12 18·59 18·20 17·57

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[3] Waller, 'On the Dosage of Chloroform,' *British Medical Journal*, April 23, 1898.

[4] *Lancet*, July 9, 1904.

This example shows that the maximum percentage afforded by 'open ether' with a closed face-piece is *approximately* 20 per cent., falling by reason of evaporation and cooling. It illustrates further that for these measurements we may take direct scale-readings without troubling to get out corrected figures.

According to my previous observations, this ether value of 20 per cent. is physiologically equivalent to the chloroform value of 2·5 per cent.

Observation 2a.—Same arrangement as in Observation 1, but no valve on the tracheal tube, so that both inspiration and expiration occurred from and to the face-piece. Temp. = 22°; bar. = 760 mm. Hg.

Time	Percentage	Time	Percentage
After 2 mins.	14·6	After 14 mins.	12
6 ,,	10·6	20 ,,	9·6
8 ,,	10·2	24 ,,	11·6
11 ,,	11·6		

Observation 2b.—The same, but with all apparatus warmed up to 30° C.:—

Time	Percentage	Time	Percentage
After 2 mins.	10	After 9 mins.	10·7
4 ,,	12	13 ,,	8·7
6 ,,	11·7	16 ,,	9·2

Observation 3.—With Sir Frederic Hewitt, to imitate as closely as possible actual procedure:—

Time	Percentage	Time	Percentage
After 2 mins.	9·7	After 8 mins.	9·3
4 ,,	9·4	10 ,,	9·3
6 ,,	10·8	12 ,,	9·7

An attempt to raise the percentage above 12 by excess of ether did not succeed, *i.e.*, there is no liability to danger by accidentally exceeding the natural maximum percentage.

The current phrase 'open ether' is used, I understand, in opposition to 'closed ether' administered from a bag such as Clover's, but does not exclude the use of a Skinner mask brought into close apposition with the face, in which case the 'opening' consists of the pores of the fabric. The essential point which is held to be secured by such an 'open method' with closed mask is that the patient is not made to breathe and rebreathe the same mixture of air, ether, and accumulating carbon dioxide. The 'open ether' method is substantially identical with the method that was shown to me in 1898 at the Massachusetts General Hospital as the regular method there practised since 1850, *i.e.*, the mask kept saturated with ether is gradually brought closer and closer to the face to give a gradually increasing percentage, until finally it is quite closely applied, so as to give the maximum percentage. It would, I think, be a suitable recognition of the pioneer work in ether

anæsthesia carried out by the American School to refer to this method of ether anæsthesia as the Boston method. The new expression 'open ether' is not justified by any novelty of procedure, and it is distinctly misleading, inasmuch as it involves the use of a closely applied face-piece.

APPENDIX III.

Six Months' Experience of the Use of a Chloroform-balance in the Out-patient Department of St. George's Hospital. By G. R. PHILLIPS, *M.R.C.S., L.R.C.P.*

Dr. Waller's chloroform-balance has been in use in the out-patient theatre of St. George's Hospital for six months. It was found at once that the machine could not deliver a sufficient volume for a normal inspiration through a ¾-inch bore pipe. A 2-gallon gas-bag was therefore placed in circuit next to the face-piece. This was found to remedy the defect, but in order to give accurate and even percentages throughout an administration it was found necessary to have an inspiratory and expiratory valve interposed between the bag and the face-piece. (When there was an expiratory valve only, expirations escaped into the bag and upset the mixture and introduced an element of rebreathing unless the pressure in the bag was sufficient to keep a constant strong outrush of chloroform-and-air. This was very wasteful of chloroform, and the fan was much noisier when working at such a pressure. Again, the chloroform was cooled much more rapidly, with a resulting fall in the percentage given.)

The apparatus should be placed in such a position that the administrator can both see the scale in the balance-case and make any alteration in the setting of the taps.

These points are of great importance, because in the use of the instrument it is absolutely necessary that the face-piece should be adjusted so that there is no leakage whatever, and that the percentage should be raised or lowered very gradually and evenly. The great advantage of the method in the out-patient department is that patients are quickly anæsthetised to the necessary depth, the average duration of induction being six minutes.

An extremely light anæsthesia or chloroform sleep can be maintained without the usual troubles of light anæsthesia for long periods, and the patients are in a better condition and ready to go home sooner than those anæsthetised by the mask and drop-bottle in ordinary hands. When the apparatus was first installed it was most unpopular with the nursing staff, but when they found that the patients were able to go home so much sooner they forgave it. With regard to the safety of the method, provided that the percentage is evenly and gradually raised, the depth of anæsthesia required for any operation is much less than by the Skinner's mask. The respirations are stronger, there is less liability to vomit during light anæsthesia in the unprepared patient. The airway is not interfered with to the same extent as it is when chloroform is dropped suddenly on to a Skinner's mask at intervals.

We have found frequently that when during a satisfactory light anæsthesia the percentage has been suddenly raised or lowered (in spite of the flywheel effect of the balance-case and reservoir-bag) vomiting

has ensued, and the after-effects have been greater than usual. The same effect is produced, of course, by removing the face-piece or allowing air to enter under the edges.

The type of anæsthesia produced by the apparatus for small operations such as the removal of needles, sebaceous cysts, ganglion of the wrist, &c., is shown by the following cases:—

Case 1.—Mary C., twenty-four years, ganglion of right hand.

Time	Percentage	Remarks
h. m.		
2 44	0	Face-piece applied.
2 45	1	Peaceful, quiet pulse, no fear or distress; holding face-piece herself until showing signs of incoordination.
2 46	1·75	
2 47	2·2	
2 48	2·2	
2 49	2·2	Ready for skin incision; *colour*, bright pink; *respiration*, quiet and even; expiration longer than inspiration, normal rate; *pulse*, normal; *eyes*, strongly resists raising lids; eyeballs rolled up and in; *pupils*, very small; *conjunctival reflex*, just present. Slight semi-conscious movements of fingers and mouth. Muttering.
2 50	2·2	Cut made. No movement. Still moaning.
2 53	2·2	Feels nothing. Slight movements irrespective of stimuli from surgeon.
2 54	2·2	Singing. No movement. Raised percentage for general convenience.
2 56	3·0	Quieter. Again moving slightly.
2 58	3·0	Pupil still, small faint stertor. Corneal reflex very brisk, does not resist raising eyelids, face-piece found to have been letting in air.
3 0	2·0	Very satisfactory; again muttering; no movement.
3 5	1·75	
3 8	1·5	Stretching begun; no reflex in wounded hand, slight movement in the other.
3 10		Face-piece removed.
3 15		Bandages put on.
3 18		Answers questions intelligently.
3 45		Dressed ready to go home. No nausea or vomiting. Feels well, slight pain in hand.

Case 2.—Louisa R., thirty-two years, twelve stone, alcoholic appearance, needle in hand.

Time	Percentage	Remarks
h. m.		
2 5	—	Face-piece applied.
2 10	3·0	
2 13	3·0	Ready for operation.
2 31	2·0	
3 0	1·5	
4 0	1·0	Face-piece removed.
4 7	—	Semi-conscious.
4 15	—	Answers questions. No vomiting or nausea.
4 25	—	Tears. Retched once.
4 30	—	Quite rational, complains of pain in the hand.
4 45	—	Dressed ready to go home, quite well. No vomiting or headache, or giddiness.

In these light stages of anæsthesia patients often have control of the pharynx. They are able to swallow saliva or small drops of water introduced into the mouth without any attempt at retching or coughing. Some patients cannot be brought up to and kept at this light level, but have to be taken through the surgical degree and gradually brought back to it. Men and alcoholics usually require as much as 3 or 3·5 per cent. to control them at first.

The majority of healthy young adults do not require more than 2·5 per cent. for this light stage.

The apparatus lends itself well to any sequence. A patient can be anæsthetised with gas and ether or ethyl chloride and transferred to 2 or 2·5 per cent. direct. The initial struggling of the alcoholic is thus aborted or more safely and easily controlled, and time is saved.

In the case of small children and infants we have discarded the face-piece and bag, preferring to play a stream of vapour over the patient while they are partly covered over by a rug in a nurse's arms. The effect upon children is even more marked than upon adults. Their colour usually remains good instead of the pallor and feeble breathing which often results from the Skinner's mask method with chloroform or a mixture of chloroform-and-ether.

The apparatus has not been used for any severe operation yet.

APPENDIX IV.

By Sir Frederic Hewitt, *M.V.O.*, *M.D.*

The chloroform-balance introduced by Professor Waller, and at the present moment installed at St. George's Hospital, has, since its transference from the laboratory to the operating theatre, taught many valuable lessons to clinical workers in the field of practical anæsthetics. It has enabled us to disentangle, so to speak, the complex phenomena of chloroform anæsthesia, to study these phenomena separately, and to refer them, at all events in many instances, to their true causation. It has indicated for us the lines upon which we should proceed if we wish to obtain the best results in practice. It has, in particular, revealed the origin and nature of certain of the difficulties and complications of general anæsthesia, and has thus suggested to us the desirability of modifying or abandoning certain methods of administration which, though advantageous from some points of view, are disadvantageous and possibly dangerous from others. The balance has thus thrown a new and philosophic light upon general anæsthesia, and though it would be wrong to claim for it that it has been wholly responsible for the fundamental change that is now taking place in this department of practice, it has fully justified those who were responsible for the formation of this Committee in the view that, by bringing the physiologist and the clinical worker into closer association, considerable improvements in anæsthetisation would result.

In addition to the great lesson taught us by the chloroform-balance and other appliances for the percentage administration of chloroform, namely, that safe anæsthetisation may be secured provided the strength of chloroform vapour does not exceed 2 per 100, there are certain other lessons to which I would now specially direct attention. The first

of these lessons is that excitement and struggling during anæsthetisation are referable, in the majority of cases in which they arise, either to (1) imperfections in the inhaling system or actual apparatus, causing suffocative sensations, or (2) irregularities in the vapour concentration, causing irritation to the mucous membrane of the upper air-passages. In this connection I would again draw attention to the importance of the 'plenum' system of administration. Any method by which the diluted anæsthetic gas or vapour is drawn through comparatively narrow channels by the inspiration of the patient is to be deprecated, not only on account of the constant stress thrown upon the respiration throughout the administration, necessitating, in certain subjects, the use of oxygen to correct the air limitation thus introduced, but on account of the excitement and struggling which such a system of administration is likely to initiate at the very outset, when a patient is conscious or semi-conscious. As is well known, the impact upon the fauces, nasopharynx, and larynx of frequently varying strengths of anæsthetic vapour is liable to produce numerous reflex phenomena, such as breath-holding, swallowing, and coughing; but it is not generally recognised that such irregular strengths are also often responsible for the struggling and excitement of the induction stage. It would seem that irregular concentrations of vapour have the same effect upon half-conscious patients as cutaneous stimuli which, as is also well known, are particularly liable to induce struggling if brought to bear during the early stages of anæsthetisation. It is found, in practice, that the more closely the anæsthetist can imitate the physiologist by presenting to his patient a dilute vapour of definite strength, or one which very gradually increases in strength, the less will be the liability to the phenomena in question. The second important lesson which we have learnt is that gradual methods of induction, although possessing certain slight disadvantages as compared with rapid methods, have the great advantage of securing *during the operation* a degree of muscular relaxation and general quietude which are rarely to be obtained when rapid and complicated methods of induction have been employed. Ever since the days of Clover the practical anæsthetists of this country have been vying with one another in their endeavours to eliminate the excitement and struggling stages of anæsthesia by the use of various anæsthetic combinations and sequences, and it may be said that they have been successful in their object. Rapidity of induction has been regarded as more or less synonymous with skill. By means of such anæsthetics as nitrous oxide and ethyl chloride, and by the use of specially constructed inhalers, it has been found possible to plunge patients into deep anæsthesia in from one to three minutes, and from some points of view such methods doubtless have much to recommend them. But, thanks to the combination of physiological experiment and clinical observation, we are now able to formulate the proposition that the use of these rapid induction methods is liable to be followed by difficulties and complications which do not present themselves when slow methods of induction have been employed. Fortunately the modern surgeon is, or should be, in no sort of hurry; and it is an easy matter for the anæsthetist to commence the anæsthetisation ten or twelve minutes before the surgeon is actually ready to begin the operation. It is true that in the

case of highly nervous subjects, as well as in other special circumstances, the loss of consciousness in from three to ten breaths, which may be relied upon, for example, in the 'gas-and-ether' sequence, is a great boon to the patient. But the anæsthetist who uses rapid methods of induction will often find himself unable to provide his surgical colleague with the best possible conditions for operating. The nervous system does not like to be taken by storm; it prefers to be gradually invaded. If taken by storm, as when some rapidly acting sequence is used, its quiescence during operations, and particularly during certain operations, is likely to be interfered with, so that various inconvenient reflex phenomena are liable to arise and to cause difficulties. On the other hand, a nervous system which has gradually been invaded by an anæsthetic will generally be found to tolerate surgical stimuli even in sensitive areas without inconvenient reflex response. The general result, therefore, is that it is usually possible after a slow induction method to work with a lighter anæsthesia than that required when a rapid induction has been employed—a distinct gain to the patient. These important differences in the eventual type of anæsthesia are often well exemplified in abdominal surgery. Whilst most patients who have been anæsthetised slowly will be found to remain tranquilly relaxed and with almost inaudible breathing during abdominal manipulations, those who have been subjected to rapid induction methods will be very liable to display laboured breathing, laryngeal spasm, or persistent abdominal rigidity—all of which may be highly inconvenient to the operator.

Whilst we are undoubtedly indebted to the chloroform-balance and to other appliances for the possibility of reducing the risk of chloroform anæsthesia almost to a vanishing point, it is questionable whether, in view of recent developments in ether administration, we shall ever witness that widespread adoption of the more potent of these two agents which some writers have regarded as inevitable. During the past year I have given a very thorough trial to so-called 'open ether,' a term now generally employed to indicate a method of administering this anæsthetic, the chief characteristic of which is almost continuous dropping of ether upon one or more layers of gauze, domet, or flannel held together by some kind of wire frame which by means of additional gauze or pads is kept more or less closely and continuously applied to the face. We are indebted, I believe, to America for this simple but exceedingly satisfactory method. I have employed it very extensively, and with such results as to justify me, I think, in predicting a long and successful reign for the method. It will be remembered that Professor Waller in Appendix I. to last year's report of this Committee referred to certain experiments which he had conducted with the object of ascertaining the percentage of ether generally inhaled during the use of the open method. Since that report the Committee has gone a step further. Having satisfied myself that the best results clinically were obtainable by the use of a Skinner's mask covered with two thicknesses of flannel, and surounded by oval 'horse collars' of gauze, the Committee instituted a series of experiments with the object of ascertaining the precise percentage of ether inhaled when ether was fully dropped upon this simple contrivance. The results obtained were remarkably constant, thus confirming the clinical observation that with

such an arrangement of flannel and gauze a most equable type of anæsthesia can be maintained. Without here entering into various clinical details, I am desirous of placing on record my complete conversion to 'open' as opposed to 'close' etherisation. I am certainly not proud of the fact that for many years my energies have been directed towards developments and improvements in a system of etherisation which, although still advantageous in certain cases, is without doubt faulty in its fundamental principles and therefore not suited for routine use. A new era in anæsthesia is commencing in this country, and it is gratifying to feel that its commencement has been determined both by clinical and by physiological considerations. We are completely abandoning the ether cone and its countless modifications. We are almost completely abandoning the time-honoured and ingenious inhalers of Clover and Ormsby, over the intricacies of which so much valuable time has been expended. Now that we know the possibilities and advantages of simpler methods and slow inductions, it is almost unintelligible that we should have tolerated these complex inhalers for so long. But it must be remembered that it is quite as much the element of slow induction as the element involved in the open method that is responsible for the success of the new system. The irregular ether percentages necessarily breathed from an ether inhaler, whether it be of the cone or reservoir type, must, as we now know, introduce difficulties which do not arise when an equable ether vapour is continuously breathed. For many years so much attention was paid in this country to the elaboration of the close system of ether administration that no one seems to have had the patience to try slow induction methods. All the teaching of earlier times was opposed to such methods. Thanks, however, partly to the example set us by American surgeons, and partly to the physiological observations made by this Committee, we now understand their advantages. Moreover, by means of appliances for securing oral as opposed to nasal respiration, by the use of atropine to lessen mucus secretion, and by the employment of morphine, and other drugs in suitable cases, to intensify the action of the anæsthetic, we are now able to avail ourselves of the striking advantages of equable etherisation free from rebreathing. We have, in a word, achieved that most difficult of all achievements—we have thrown off elaborations and complications one by one till we have secured the utmost simplicity in procedure, and as that simplicity is associated with a corresponding degree of safety, there seems every probability that less and less will be heard of rival appliances for the percentage administration of chloroform and more and more of this new system of etherisation.

Body Metabolism in Cancer.—Interim Report of the Committee, consisting of Professor C. S. Sherrington *(Chairman) and* Dr. S. M. Copeman *(Secretary).*

In continuation of the experimental work on mice, an account of which was given in the report for last year, we had proposed to test the effect on the human subject of various substances derived from the genital glands, more especially nuclein and its derivatives.

Unfortunately, considerable difficulty has been experienced in obtaining the necessary material, and it is only within the last few months that, thanks to the generosity and enterprise of Messrs. Parke, Davis, & Co., sufficient nuclein of animal origin has become available. Certain preliminary tests have been carried out with the object of determining the most satisfactory method of administration, the dosage, etc. The work has been controlled by careful observation of the effect produced, more especially on the elimination of phosphates in the urine, the daily output of which has been found to be considerably diminished, both relatively and absolutely, in cases of malignant disease.

At the present stage, however, it is impossible to present any detailed statement, and we therefore propose the reappointment of the Committee for another year, without further grant of money, as last year's residue is still in hand.

Tissue Metabolism, for the Investigation of the Metabolism of Special Organs.—Report of the Committee, consisting of Professor E. H. STARLING *(Chairman),* Professor T. G. BRODIE *(Secretary), and* Dr. J. S. HALDANE.

THE gaseous metabolism first investigated by the Committee was that of the small intestine. A good length of the intestine was isolated and the interior thoroughly washed out with warm saline and then emptied. The loop was then enclosed in an oncometer, so that the rate of blood-flow could be estimated by Brodie's oncometric method. Samples of the venous blood were collected from a neighbouring branch of the mesenteric vein. Detailed results of these experiments have been published in the 'Journal of Physiology,' vol. xxxix.

In the next instance preliminary experiments upon the gaseous metabolism of isolated organs have been undertaken. In the first place, organs perfused with oxygenated saline solutions were examined. This involved an extension of the previous methods of analysis of gases in saline solutions, and apparatus has been designed for the purpose. The results of these experiments agree well with those obtained by other methods, so that this method will probably serve for the investigation of many problems which it would be impossible to attempt in the intact organ.

The Ductless Glands.—Report of the Committee, consisting of Professor SCHÄFER *(Chairman),* Professor SWALE VINCENT *(Secretary),* Professor A. B. MACALLUM, Dr. L. E. SHORE, *and* Mrs. W. H. THOMPSON. *(Drawn up by the Secretary.)*

MRS. THOMPSON has been continuing her investigations into the neck organs (thyroid, parathyroid, post-branchial body, carotid body, ventral branchial body, thymus, pro-coracoid, and pro-pericardial bodies). During the past year her attention has been chiefly directed to these various structures in the frog and other amphibians. One interesting fact which has come to light is that in frogs the thymus

gland is frequently absent, or at least is not to be detected, at certain periods of the year (in certain states of nutrition?).

Drs. Halpenny and Gunn are engaged in experimental work upon the thyroid and parathyroid. The results of a series of extirpation experiments upon monkeys are recorded in the 'Quart. Journ. of Exp. Physiol.,' vol. iv., No. 3 (1911). The effects differ in some respects from those reported by Horsley and by Vincent and Jolly.

Drs. Gardner and Mothersill have been occupied with extirpation of the adrenals in the dog, and the effect of such extirpation upon the chromaphil tissues which are left behind. So far as the experiments have gone they appear to indicate that when the animal survives for some time with a minimum of adrenal substance, there is a notable hypertrophy of the abdominal chromaphil body.

The pituitary bodies of the monkeys whose thyroid apparatus was removed are being examined histologically, but the work is not sufficiently advanced for a report.

The Committee ask to be reappointed with a grant of 40*l*.

Electromotive Phenomena in Plants.—Report of the Committee, consisting of Dr. A. D. Waller *(Chairman)*, Mrs. Waller *(Secretary)*, Professors F. Gotch *and* J. B. Farmer, *and* Drs. V. H. Veley *and* F. O'B. Ellison.

The purpose for which this Committee was originally appointed has gradually become transformed from the particular investigation of the ferments involved in flowering to that of the electrical changes associated with fermentation of plants. In our last report we described the associated chemical and electrical phenomena that characterise the production of hydrocyanic acid in the cherry laurel (*Prunus laurocerasus*).

We have continued our observations during the past year, more especially as regards the nature of the electrical changes involved. The results of our investigation, which is not yet finished, are contained in two papers, the first of which has been communicated to the Royal Society. A second paper is in preparation.

In pea and bean seedlings the normal electric current runs from the cotyledons up the stem and amounts sometimes to 0·08 volt. The blaze current runs from the growing tip of stem towards the cotyledons.

Cutting the stem across causes a current from the cut end of 0·02 volt or more, which subsides in about half an hour.

A sharp touch sends a current from the point touched and, as Dr. Waller has shown, the touch of a fine hair on young stems will cause an electrical current from that point.

A series of observations was taken on the relative effects of water, salt solution, ether, and chloral on the blaze currents, using hyacinth root tips as the object to be studied.

In the water the blaze increased from 0·0080 volt to 0·0300 in three days; in salt solution it decreased from 0·0080 volt to 0·0040; in ether from 0·0070 volt to 0·0013; and in chloral from 0·0020 volt to 0·0001,

Mental and Muscular Fatigue.—Report of the Committee, consisting of Professor C. S. SHERRINGTON (*Chairman*), Dr. W. McDOUGALL (*Secretary*), Professor J. S. MACDONALD, Mr. H. SACKVILLE LAWSON, *and* Dr. J. E. CHAPMAN.

THE Committee report that Professor MacDonald and Dr. J. E. Chapman have been working during the past year with the large calorimeter of the Sheffield University physiological laboratory and have made good progress in mastering the many difficulties involved in exact determination of heat production in the human body. A statement of the nature of their work is appended. Mr. Sackville Lawson has continued his investigation into mental fatigue in schoolboys. The sum of 9*l.* has been assigned to him in order to complete the purchase of the Rivers-McDougall fatigue-apparatus which he is using. The remainder of the grant of 25*l.* has been assigned to Professor MacDonald and Dr. Chapman to defray expenses of their calorimetric research.

Report to the Committee. By Professor J. S. MACDONALD *and* Dr. J. E. CHAPMAN.

We report a year spent in the development and use of a calorimeter built, as far as its body is concerned, on the plan, and with the dimensions, of the Middletown calorimeter of Atwater and Benedict. In many minor details, however, we have found it useful to depart from that plan, as in the construction of the radiator system, the resistance thermometers, &c.

Not intending to measure the respiratory exchange of gases at present, we are freed from limitations due to the dimensions and resistance of absorption apparatus. We have thus used a greater air-flow, the pump now in place drawing 450 cubic feet per hour through the calorimeter. This air passes into the chamber without preliminary treatment other than modification of its temperature to suit that of the calorimeter, and in this increased air-flow and its normal character we have obtained certain advantages.

Our arrangements for each experiment have been greatly facilitated by the discovery of a relationship between the heat output within the chamber and the temperature of the calorimeter and radiator system such that

$$H = k\left(T_c - \frac{T_e + T_1}{2}\right)$$

where H is the heat output, T_c is the temperature of the calorimeter, and T_e and T_1 the temperatures of the water entering and leaving the radiator system respectively. This equation, containing as it does no quantity concerned with the rate of water flow, has been of considerable use. For a physical explanation of this observed fact we have to thank Mr. J. Robinson, M.Sc., Ph.D.

Using the calorimeter simply for the purposes of heat measurement, and not as a respiration calorimeter, we have had to deal with water vapour leaving the instrument solely as it affected the heat equations,

and have therefore had to pay nothing more than secondary attention to the amount of water condensing on, or evaporating from, the radiator in the calorimeter. We have thus been set free from any necessity for weighing the water that is condensed within the calorimeter.

Measurements of the water vapour leaving the calorimeter were obtained at first by direct weighing of absorption apparatus placed in its path, but we have now substituted 'wet and dry' bulb readings taken in an accessory chamber of suitable dimensions, and apparently with advantage.

One of the greatest difficulties experienced at first was the great delay in the external delivery of heat which was due to the great heat capacity of the calorimeter. This has been satisfactorily eliminated by observations which have given us its 'water equivalent' and a means of rendering all our figures free from this source of error. Using these corrections we are enabled to express our experimental results in continuous curves showing variations in heat production of quite short duration.

That item in the construction of Atwater and Benedict's calorimeter which appeared at first as likely to need an extraordinary amount of experience in handling—namely, the equalisation of the temperature of the metal box surrounding the calorimeter to the temperature of the calorimeter in its several sections—we have found much more simple than was anticipated, and have now proof that it is managed with perfect success.

The only occasions when difficulties arise in this matter are when very great changes occur in the amount of heat produced within the calorimeter. To meet these special difficulties we have placed within the calorimeter an extra source of heat, a number of incandescent lamps, using them frequently to balance such violent changes. We have considerable evidence to support the statement that no new errors of moment are introduced by this plan. It has the further advantage that the interior of the calorimeter is lighted and its occupant always visible.

In our more recent experiments we have been enabled to take the records of the occupants' temperature using the thermo-couple method elaborated by Gamgee, and have thus now all the data required for an estimation of the heat production of man as distinguished from his heat elimination.

In expressing the results of experiments it has been found essential to take full account of the surface of each subject; a consideration of the published results of others and of our own direct measurements have led us to adopt a modified formula for the surface in terms of the data of height and weight

$$S = 3H\sqrt[3]{W}$$

A large number of experiments have been carried out with a number of subjects under conditions of rest, sleep, and work, and we hope in a short time to publish a full account of these experiments and their bearing upon the questions referred to this Committee.

Clare Island.—Report of the Committee, consisting of Professor T. JOHNSON (*Chairman*), Mr. R. LLOYD PRAEGER (*Secretary*), Professor GRENVILLE COLE, Dr. SCHARFF, *and* Mr. A. G. TANSLEY, *appointed to arrange a Botanical, Zoological, and Geological Survey of Clare Island.*

THE Committee desire again to thank the British Association for a grant in aid of the expenses of field work. This grant has been spent in defraying travelling expenses and incidentals connected with the survey. On account of the nature of the expenditure, vouchers are not available.

The Committee hope to finish their work on Clare Island by the end of the present year, and ask for a further and final grant of 30*l.* to assist them in accomplishing this.

The Structure of Fossil Plants—Report of the Committee, consisting of Dr. D. H. SCOTT (*Chairman*), Professor F. W. OLIVER (*Secretary*), Mr. E. A. NEWELL ARBER, *and* Professors A. C. SEWARD *and* F. E. WEISS.

THE grant of 15*l.* has all been spent. A series of sections of a new coal-measure *Trigonocarpus* has been purchased for Professor F. W. Oliver, who is describing this Palæozoic seed.

For Professor Weiss a number of sections of coal-balls and of the coal itself has been obtained, to enable him to investigate the distribution of plant-remains within the coal-seam, with a view to finding a clue to a possible succession of different stages or types of vegetation.

Other sections acquired are of *Stigmaria* and allied forms, on which Professor Weiss has long been working.

The Experimental Study of Heredity.—Report of the Committee, consisting of Mr. FRANCIS DARWIN (*Chairman*), Mr. A. G. TANSLEY (*Secretary*), *and* Professors BATESON *and* KEEBLE.

THE grant of 45*l.* has been used to defray the expenses of experiments carried on by E. R. Saunders, R. P. Gregory, and M. G. Thoday.

During the present year the experiments on the inheritance of double flowers have been continued. In the case of stocks the results have now shown that this character is inherited in accordance with definite though somewhat complicated laws. It is hoped that the full account will appear in the autumn.

Similar experiments have also been carried out on several other genera, chiefly biennials (carnation, hollyhock, meconopsis, wallflower, and others). These have now been carried to the third generation, and when this season's results have been obtained it is proposed to give some account of the inheritance in these cases also.

Investigations are also being continued on the inheritance of a mutation in the foxglove.

The investigations into the inheritance of colour in *Primula sinensis* have been carried further, and attention has been paid to the genetics of parti-coloured and flaked types. Experiments bearing upon the special relations which are found to exist between certain distinct factors have given interesting results,[1] and are being carried further.

The inheritance of an abnormal type of flower in the wallflower is being investigated, and experiments are also being made with a putative hybrid between two species of *Taraxacum*.

Mrs. Thoday has continued her experiments on the nature and inheritance of the yellow tinge in the sweet pea [2]

Botanical Photographs.—Report of the Committee, consisting of Professor F. W. OLIVER (*Chairman*), Professor F. E. WEISS (*Secretary*), Dr. W. G. SMITH, Mr. A. G. TANSLEY, Dr. T. W. WOODHEAD, *and* Professor R. H. YAPP, *for the Registration of Negatives of Photographs of Botanical Interest.*

IN accordance with the wish expressed by the Committee of the Botanical Section at the Sheffield Meeting of the Association, the second list of photographs collected by the Committee has been printed and distributed to the botanical members of the Association. This list includes mainly single plants or groups of plants, either in their natural habitat or under cultivation. Owing to special circumstances it has been impossible this year to prepare and publish a list of the ecological photographs which have so far been collected. It is hoped that this may be done next year, and with this object in view the Committee ask to be reappointed.

Mental and Physical Factors involved in Education.—Report of the Committee, consisting of Professor J. J. FINDLAY (*Chairman*), Professor J. A. GREEN (*Secretary*), Professors J. ADAMS *and* E. P. CULVERWELL, Mr. G. F. DANIELL, Miss B. FOXLEY, Mr. J. GRAY, Professor R. A GREGORY, Dr. C. W. KIMMINS, Mr. W. McDOUGALL, Dr. T. P. NUNN, Dr. W. H. R. RIVERS, Professor C. SPEARMAN, Miss L. EDNA WALTER, *and* Dr. F. WARNER, *appointed to inquire into and report upon the methods and results of research into the Mental and Physical Factors involved in Education.*

THE following were co-opted to the Committee: Dr. G. A. Auden, Sir Edward Brabrook, Dr. W. Brown, Dr. C. P. Lapage, Mr. H. S. Lawson, Dr. C. S. Myers, Dr. F. C. Shrubsall, Mr. H. Bompas Smith, and Mr. A. E. Twentyman.

The Committee have conducted an inquiry during the past year on the tests actually in use and to be used in the diagnosis of feeble-minded

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[1] *Proc. Roy. Soc.*, Sec. B, vol. 84, p. 13, 1911.

[2] *Proc. Cambridge Phil. Soc.*, vol. 16, p. 71, 1910.

children. To that end they have circulated the following questionnaire among School Medical Officers in whose districts Special schools for this class of children were provided:—

1. By what process are the children chosen for examination by you?
2. What methods and tests have you employed for determining whether those children should be accepted in the schools for children of defective mental power?
3. Do you use any specially designed tests, *e.g.*, Binet's, Weygandt's, de Sanctis', &c.?
4. Which of the various methods you have used do you prefer, and why?
   (It would help the Committee greatly if you would comment freely upon the various tests you have used.)
5. Have you evolved any special tests for routine or for exceptional cases?
6. How do you test the progress of the children when they are in the schools? (A copy of the form of record would be a help.)
7. Is there any 'psychological' classification of the children in the Special schools?
8. Do you take into consideration such factors as age, irregularity of attendance at school, frequent change of schools, physical defect, &c.?
9. What method do you adopt to determine whether (*a*) a boy, (*b*) a girl, may leave the Special school before the statutory limit of sixteen years?
10. Do you make any provision for sane 'epileptics'? Have you any after-care committee to continue supervision after school age?

A second set of questions were addressed to the headmistresses of Special schools, as under:—

1. Number of children in the school aged 16, 15, 14, 13, 12, 11, 10, 9, 8, and 7.
2. Number (of those now in the school) admitted at 16, 15, 14, 13, 12, 11, 10, 9, 8, and 7.
3. Into how many classes are they divided?
4. What is the basis of classification and how is promotion determined? (A copy of your record form would be helpful.)
5. Have any children ever gone back from your school to the ordinary school? If so, how many?
6. Do you make any psychological classification of the various forms of mental defect and base your treatment upon it? If so, will you kindly describe it.
7. What proportion of the children reach the normal proficiency of a Standard II. child in respect of the three R's?
8. How much time is given to manual work? What is the nature of it? Is it brought into relation with the ordinary work of the class-room, or is it outside your control?

The Committee have received answers to these questions from the following Education Authorities: London, Liverpool, Manchester, Birmingham, Sheffield, Leeds, Bristol, Nottingham, Leicester, Blackburn, Colchester, Smethwick, Eastbourne, Brighton, Middlesbrough, Wolverhampton, Coventry, Willesden, Southend. The information they have collected may therefore be regarded as fairly representative of the country as a whole.

The summarised replies to the questions are given in Appendices I. and II. to this Report. The several Education Authorities are indicated by capital letters in the first column.

The Committee would draw attention to the grave need of some standardisation in the matter both of diagnosis and subsequent treatment. A study of the replies will show:—

1. That the actual standards of admission to the schools vary very greatly in different parts of the country, for, whilst in some cases the return of a child from the Special school to the Ordinary school is said to be very frequent, in others it never occurs. One Medical Officer frankly says that he should regard return as indicating an error in diagnosis in the first instance.

2. That this varying standard is accompanied by great variety in methods of testing. Both teachers and doctors find great difficulty with border-line cases, and it is clear that much careful research is necessary in order that it may be possible to decide with some measure of certainty between backwardness and mental defect.

3. That the number of late entries into Special schools is disproportionately large. This may be in part due to the recent provision of such schools in some areas, and in part to the natural desire of parents and teachers to avoid the stigma which seems to attach to the Special school.

4. That the number of children who remain in the Special schools until the full statutory age is very small. This is apparently not due to transfers to the ordinary school, but to the fact that the children are allowed to leave school earlier than is necessary.

5. That the attempt to teach the three R's is a lamentable failure, whilst the amount of time given to manual training is in many cases altogether inadequate. If the greater part of school time were devoted to hand work of distinctly useful character, probably much better results would be achieved. Work in the three R's might in many cases actually be confined to such as arose out of the manual work, where it would have an obvious meaning and use.

6. In deciding this and other educational problems diagnosis of a scientific character seems essential. A wider acquaintance among teachers with modern psychological methods is desirable, especially in the interest of backward and mentally defective children.

7. There is no apparent relation between diagnosis and treatment in the Special schools. This is no doubt due to want of precise knowledge on types of mental defect in relation to the general problem of educability. Research on this point seems to the Committee both possible and urgently needed.

8. That special provision for backward and delicate children on the Mannheim plan seems urgently necessary. This would be possible in most districts in which Special schools for the mentally deficient are organised.

A third questionnaire was circulated fairly widely amongst teachers in elementary schools in the hope of finding out how far the Medical Officers and the Teachers were in agreement on the subject of mental deficiency:—

1. Under what circumstances do you decide to submit a child to the Medical Officer as being, in your view, unfitted to profit by the ordinary instruction in your school?

2. Are children promoted from the Infants' department on grounds of age?
3. Have you any experience of children whom you have recommended in this way being rejected by the Medical Officer?
(If you can give the number of cases and the subsequent school history of such children we should be grateful.
4. Have you in your school any special class for dullards of all ages? If so, how many are in the class, and how do you provide for them?

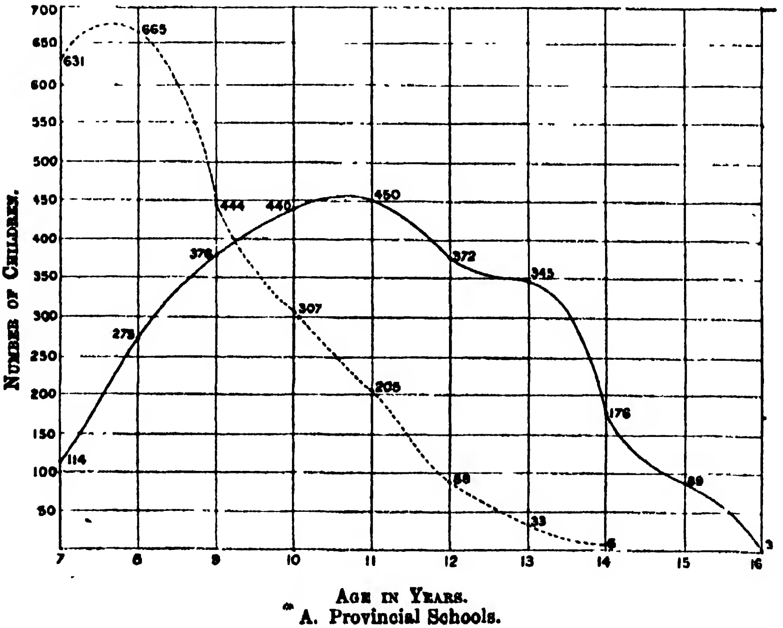
It was, however, not clear that any very wide disagreement existed so far as the inquiry went, but here and there dissatisfaction was expressed, and, in the Committee's view, some more careful diagnosis should be attempted before the teacher's cases are rejected by the Medical Officer. Where the resources of a psychological laboratory are available, these might be used with advantage.

In concluding their report, the Committee would wish to thank the Medical Officers and Headmistresses of Special schools for the care they have taken in supplying the information asked for. The Committee desire to be reappointed.

APPENDIX II.

Summary of Returns from Heads of Defective Schools.

——— Shows the ages of the children now in defective schools. (Q. 1.)
……… Shows the ages of admission of children now in these schools. (Q. 2.)



A. Provincial Schools.

APPENDIX I.

Summary of Returns from Medical Officers.

(The towns are indicated by letters which have no reference to the order of the towns as given in the Report—more precise confidential information may be obtained from the Secretary of the Committee.)

The numbers at the head of the columns refer to the number of the question.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
	Method of Selection	Tests used for acceptance, or otherwise	Specially designed tests (Binet or other) used	Which tests preferred	Routine or special case tests designed	Tests for progress	Psychological classification	Age, irregularity, and like factors, physical defect	Tests for leaving before 16	Provision for sane epileptics? After-care Committee?
A	Report of Head Teacher, School Inspector, or Medical Inspector	*a* H.T. fills up a prescribed form. *b* Children tested in regard to i. General intelligence. ii. Recognition of common objects. iii. Number, colour, reading, writing, and counting. iv. Sensory condition.	No.	Test explained in No. 2.	No; test varied according to condition of child.	Record-book kept.	Three classes—Low, Middle, and High.	When admitting, yes. When classifying, no.	Quarterly examination; child must be noticed.	A few children sent to colony for epileptics. No committee.
B	Reports of Medical Inspectors referred to Medical Superintendent of the City Asylum	No special method. Careful examination of physical, mental, and moral condition of child.	No.	—	No.	Annual examination in all cases. Intermediate examination for special cases. Case book kept and special form used.	Classified according to *a.* Knowledge possessed. *b.* Capacity for learning.	No.	When child can derive no further benefit from school	No. Yes.
C	Reports of Medical Inspectors, Head Teachers, and Attendance Officers. Tested by Medical Officer of Health	See Chap. VII., Shuttleworth and Potts. Report on i. Family history. ii. Aspect and peculiarities. iii. Physical condition. iv. Mental condition. v. School attendance.	No—lack of time.	In private practice, Binet's tests have been found useful, but difficult to compile set of tests to suit *all* defectives.	See Question 2. The manner of the examiner of more importance than the nature of the test.	1. By test questions (age, day of month, &c.). 2. Teacher's Quarterly Report Book.	Children grouped for convenience of teaching; not desirable to segregate according to psychological defects.	Certainly. Much importance attached to physical defects.	Can the child benefit by instruction in an Elementary school?	Yes; sent to Lingfield or other school. Yes; committee connected with N.A.F.M.; teachers co-operate and keep in touch with former pupils by social gatherings.
D	Reported by Head Teachers—examined by Schools Medical Officer	i. History. ii. Cranial abnormalities. iii. Calculation, reading, memory, attention, &c.	Tests not known.	Examination of all the senses of the child, and comparison with normal.	No.	Bi-annual examination.	No.	Yes.	If child can compete with his fellows.	No. Yes.
E	Report of teachers and Attendance Officers. Selection by Medical Officer.	*a.* Attitude, aspect, expression, gait, nutrition, physical abnormalities. Hands and fingers. Eye movements. Action of nervous system. Rapidity of response. Articulation. *b.* Experience of teacher. *c.* Experience of parent.	No.	—	—	Periodical visits. Repetition of 2.	Classification according to progress in school work.	Infants and children about to leave Elementary school not admitted. Other factors not considered.	Can child earn own living? Can he take place in Elementary school?	No.
F	Report of Head Teacher.	Those recommended by the Board. Special observations regarding i. Imitation of movement. ii. Reinforcement of movements. iii. Muscular sense. iv. Spontaneity. v. Physical defects.	No.	Only method of making diagnosis by general conclusions.	No.	Monthly examination. Detailed examination twice a year—this is recorded.	No.	Yes.	Progress according to Record-book.	Sane epileptics attend Elementary schools. No.
G	Reported by teachers of Infant Schools.	1. Family and personal history, stigmata. 2. Motor control, observation, and gait. Attention, colour, size, and number. Reading, writing, drawing. Repetition.	No.	—	—	Record kept of child's capabilities.	—	Yes. Those who are backward owing to ill health are put into special 'backward' classes.	If the work to which the child is going is suitable and educational, child may go on probation, watched by Attendance Officers.	No special provision. Yes.
H	Reported by teacher to School Medical Officer.	1. Examination of children and of the school work by School Medical Officer. 2. Reports of parents and teachers. 3. Tests according to necessity.	No.	Personal judgment of S.M.O.	No.	Record kept—usual type.	No.	Yes.	Personal examination and consultation with the teacher.	Not specially; mild cases remain in Elementary schools, others, when possible, sent to Special schools for epileptics. Yes, but arrangements not very definite.
I	References by— *a.* Head Teacher. *b.* Parents. *c.* Attendance Officers. *d.* School doctor.	1. General physical examination. 2. Mental factors: inquiries respecting— Reading, writing, and number. General intelligence, attention, imitation, self control, habit.	No.	—	No.	Examination twice a year: report kept; progress estimated by comparison with previous reports; manual and mental attainments examined.	No. Three grades, according to educational attainments.	Yes.	1. If suitable work be offered. 2. If incapable of further tuition. 3. If morally defective, or exerting bad influence over others. 4. If capable of attending Elementary school.	1. Fits infrequent: Elementary school, special instructions to teachers. 2. Fits frequent: special institution. Yes, but not very satisfactory.
J	Children of a certain age are selected by Head Teacher as unteachable, then submitted to Mistress of Special School	Written report of Head Teachers. Form recommended by the Board of Education.	No.	See above.	No.	Yearly examination.	According to intellectual attainments.	Yes.	Not yet considered.	Sane epileptics in Elementary schools. Guild of Help.
K	*a.* By the teacher. *b.* By Special Medical Officer.	See Appendix III.	Binet's and some of de Sanctis'.	Dr. Hogarth's tests, multiple writing tests, Demoor's Weight-size Illusion.	See 4.	Half-yearly examinations.	To a slight extent, into aural, visual, and motor. But classes get mixed up, and 80 per cent. are either no type at all or predominantly motor.	Yes.	*a.* Ineducable. *b.* Mental limit reached. *c.* Fit for ordinary school. *d.* Invalid. *e.* Fair attainments, and suitable employment available.	A few sent to a colony. Yes.
L	Picked out by teachers, examined by Special Medical Officer.	*a.* Physical examination. *b.* Mental examination. *c.* Family history. *d.* Personal history.	No.	—		Half yearly examinations by S.M.O.—record kept.	No.	Yes.	*a.* Suitable work. *b.* Incapable of further instruction.	No. After-care Committee once active: now quiescent.
M	Reported by— *a.* Head Teacher. *b.* Assistant Medical Officer. *c.* Secretary to the Education Authority, to Special Medical Officer.	*a.* Physical examination. *b.* Mental examination i. Response to stimulation—sight; cutaneous. ii. Attention—re-sorting, playing-cards. iii. Memory—copying a figure; questions about familiar objects; questions about home circumstances. iv. Reasoning—untying knots; zig-zag puzzle.	No.	1. Attention. 2. Memory—particularly important. 3. Reasoning.	No.	*a.* Head Teacher's report. *b.* Observation of manual work.	No.	Yes—particularly age.	Child able to earn living, and home circumstances are poor.	No. Yes.
N	Selected by Head Teachers and Medical Inspectors. Submitted to Medical Officer of Mentally Defective Schools	1. Knowledge of letters or the simplest words. 2. Simple numerical processes. 3. Recognition of subjects of simple pictures. 4. Number and name of brothers and sisters. 5. Differentiation of everyday coins and of colours. 6. Number and order of the days of the week. 7. Familiarity with some well-known local matters.	No: demeanour, especially lack of concentration and attention, counts for much.	Imperfect response to several of the above tests.	Generally, work systematically through above.	Inspection twice a year: fuller examination of children specially noted by Head of Defective School.	Grouping in classes, according to mental defect.	Yes, such factors often show that the child is dull or backward, rather than defective.	Special examination of those *a.* who seem too bad to remain. *b.* who seem to have a chance of holding their own in an ordinary school.	Confirmed epileptics, even if sane, are not admitted. Yes.
O	*a.* By teachers after examination by Committee's Inspector. *b.* By Assistant School Medical Officer.	*a.* Children tested in reading, writing, dictation, number, description, answering easy questions. *b.* Physical examination of eyes and ears. *c.* Inquiries as to home conditions.	No.	—	—	—	No, according to ability in occupations.	Yes, always.	*a.* Satisfactory work. *b.* Incapable of receiving benefit from further instruction.	No. Yes.
P	Selected— *a.* By H.T.'s. *b.* During medical inspection.	*a.* General appearance, stigmata, muscular tone, and co-ordination, gait. *b.* Speech, general knowledge, observation and attention, ability to carry out simple actions involving judgment, memory, &c.	Binet's tests applied, but not rigorously.	—	—	By comparison of educational attainment, gait, speech, &c., with previous examinations of these.	No, according to educational attainment.	Yes.	*a.* Unimprovable. *b.* Occasionally, if defect is slight. *c.* Others remain in school until age of sixteen.	One epileptic boarded out at a special school. Committee in process of formation.
Q	*a.* Reports of School Medical Officers, checked by teachers. *b.* Selected by H.T.'s. *c.* Reported by parents. *d.* Reported by Attendance Officers.	Sensitiveness to stimulation. Attention. Memory. Reasoning. Morals (from friends and teachers). Muscular co-ordination. Physical condition. (Classification of Royal College of Physicians.)	No.	—	—	By tests mentioned in Q. 2.	See replies to Question 6 on the schedules filled in by the Head Mistresses.	Yes, all these factors are considered.	Each child carefully examined and record form considered.	No; there are a few mild cases of epilepsy in the Special schools. Yes; an After-Care Committee is attached to each Special school.
S	After reference by Assistant Medical Officers, Head Teachers, Attendance Officers, &c.	*a.* Forms filled up by Head Teacher. *b.* Children tested in regard to 1. Observation. 2. Intelligent memory. 3. Attention. 4. Mental peculiarities, stability, &c. 5. Number. 6. Speech. 7. Habits. 8. Three R's. 9. Manual dexterity.	No.	—	Many adapted to various types have been evolved and collected from various sources.	By comparing what they can do at a subsequent examination and by teacher's records.	All so classified, but impracticable to keep them separate in schools.	As a matter of routine.	Possibility of further progress, nature of employment offered, home conditions and child's influence on others.	Residential school for sane epileptics. No After-Care Committee.

To face p. 180.]

APPENDIX I.

Summary of Returns from Medical Officers.

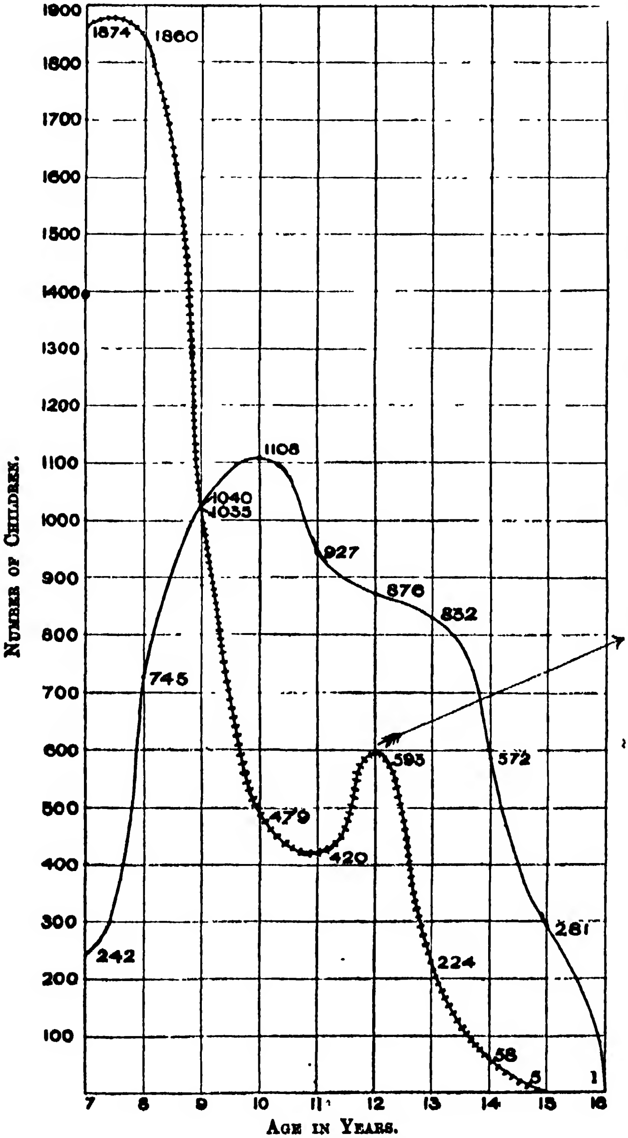
(The towns are indicated by letters which have no reference to the order of the towns as given in the Report—more precise confidential information may be obtained from the Secretary of the Committee.)

The numbers at the head of the columns refer to the number of the question.

	1. Method of Selection	2. Tests used for acceptance, or otherwise	3. Specially designed tests (Binet or other) used	4. Which tests preferred	5. Routine or special case tests designed	6. Tests for progress	7. Psychological classification	8. Age, irregularity, and like factors, physical defect	9. Tests for leaving before 16	10. Provision for sane epileptics? After-care Committee?
A	Report of Head Teacher, School Inspector, or Medical Inspector.	a. H. T. fills up a prescribed form. b. Children tested in regard to i. General intelligence. ii. Recognition of common objects. iii. Number, colour, reading, writing, and counting. iv. Sensory condition.	No.	Test explained in No. 2.	No; test varied according to condition of child.	Record-book kept.	Three classes—Low, Middle, and High.	When admitting, yes. When classifying, no.	Quarterly examination; child must be normal.	A few children sent to a colony for epileptics. No committee.
B	Reports of Medical Inspectors referred to Medical Superintendent of the City Asylum.	No special method. Careful examination of physical, mental, and moral condition of child.	No.	—	No.	Annual examination in all cases. Intermediate examination for special cases. Case book kept and special form used.	Classified according to a. Knowledge possessed. b. Capacity for learning.	No.	When child can derive no further benefit from school.	No. Yes.
C	Reports of Medical Inspectors, Head Teachers, and Attendance Officers. Tested by Medical Officer of Health.	See Chap. VII., Shuttleworth and Potts. Report on i. Family history. ii. Aspect and peculiarities. iii. Physical condition. iv. Mental condition. v. School attendance.	No—lack of time.	In private practice, Binet's tests have been found useful, but difficult to compile set of tests to suit *all* defectives.	See Question 2. The manner of the examiner of more importance than the nature of the test.	1. By test questions (age, day of month, &c.). 2. Teacher's Quarterly Report Book.	Children grouped for convenience of teaching; not desirable to segregate according to psychological defects.	Certainly. Much importance attached to physical defects.	Can the child benefit by instruction in an Elementary school?	Yes; sent to Lingfield or other school. Yes; committee connected with N.A.P.M.; teachers co-operate and keep in touch with former pupils by social gatherings.
D	Reported by Head Teachers examined by Schools Medical Officer.	i. History. ii. Cranial abnormalities. iii. Calculation, reading, memory, attention, &c.	Tests not known.	Examination of all the senses of the child, and comparison with normal.	No.	Bi-annual examination.	No.	Yes.	If child can compete with his fellows.	No. Yes.
E	Report of teachers and Attendance Officers. Selection by Medical Officer.	a. Attitude, aspect, expression, gait, nutrition, physical abnormalities. Hands and fingers. Eye movements. Action of nervous system. Rapidity of response. Articulation. b. Experience of teacher. c. Experience of parent.	No.	—	—	Periodical visits. Repetition of 2.	Classification according to progress in school work.	Infants and children about to leave Elementary school not admitted. Other factors not considered.	Can child earn own living? Can he take place in Elementary school?	No.
F	Report of Head Teacher.	Those recommended by the Board. Special observations regarding i. Imitation of movement. ii. Reinforcement of movements. iii. Muscular sense. iv. Spontaneity. v. Physical defects.	No.	Only method of making diagnosis by general conclusions.	No.	Monthly examination. Detailed examination twice a year—this is recorded.	No.	Yes.	Progress according to Record-book.	Sane epileptics attend Elementary schools. No.
G	Reported by teachers of Infant Schools.	1. Family and personal history, stigmata. 2. Motor control, observation, and gait. Attention, colour, size, and number. Reading, writing, drawing. Repetition.	No.	—	—	Record kept of child's capabilities.	—	Yes. Those who are backward owing to ill-health are put into special 'backward' classes.	If the work to which the child is going is suitable and educational, child may go on probation, watched by Attendance Officers.	No special provision. Yes.
H	Reported by teacher to School Medical Officer.	1. Examination of children and of the school work by School Medical Officer. 2. Reports of parents and teachers. 3. Tests according to necessity.	No.	Personal judgment of S.M.O.	No.	Record kept—usual type.	No.	Yes.	Personal examination and consultation with the teacher.	Not specially; mild cases remain in Elementary schools, others, when possible, sent to Special schools for epileptics.
I	References by— a. Head Teacher. b. Parents. c. Attendance Officers. d. School doctor.	1. General physical examination. 2. Mental factors—inquiries respecting— Reading, writing, and number. General intelligence, attention, imitation, self control, habit.	No.	—	No.	Examination twice a year—report kept; progress estimated by comparison with previous reports; manual and mental attainments examined.	No. Three grades, according to educational attainments.	Yes.	1. If suitable work be offered. 2. If incapable of further tuition. 3. If morally defective, or exerting bad influence over others. 4. If capable of attending Elementary school.	Yes, but arrangements not very definite. 1. Fits infrequent—Elementary school, special instructions to teachers. 2. Fits frequent—special institution. Yes, but not very satisfactory.
J	Children of a certain age are selected by Head Teacher as unteachable, then submitted to Mistress of Special School.	Written report of Head Teachers. Form recommended by the Board of Education.	No.	See above.	No.	Yearly examination.	According to intellectual attainments.	Yes.	Not yet considered.	Sane epileptics in Elementary schools. Guild of Help.
K	a. By the teacher. b. By Special Medical Officer.	See Appendix III.	Binet's and some of de Sanctis'.	Dr Hogarth's tests, multiple writing tests, Demoor's Weight-size Illusion.	See 4.	Half-yearly examinations.	To a slight extent, into aural, visual, and motor. But classes get mixed up, and 80 per cent are either no type at all or predominantly motor.	Yes.	a. Ineducable. b. Mental limit reached. c. Fit for ordinary school. d. Invalid. e. Fair attainments, and suitable employment available.	A few sent to a colony. Yes.
L	Picked out by teachers, examined by Special Medical Officer.	a. Physical examination. b. Mental examination. c. Family history. d. Personal history.	No.	—		Half-yearly examinations by S.M.O.—record kept.	No.	Yes.	a. Suitable work. b. Incapable of further instruction.	No. After-care Committee once active; now quiescent.
M	Reported by— a. Head Teacher. b. Assistant Medical Officer. c. Secretary to the Education Authority, to Special Medical Officer.	a. Physical examination. b. Mental examination i. Response to stimulation—sight; cutaneous. ii. Attention—re-sorting, playing-cards. iii. Memory—copying a figure; questions about familiar objects; questions about home circumstances. iv. Reasoning—untying knots; zig-zag puzzle.	No.	1. Attention. 2. Memory—particularly important. 3. Reasoning.	No.	a. Head Teacher's report. b. Observation of manual work.	No.	Yes—particularly age.	Child able to earn living, and home circumstances are poor.	No. Yes.
N	Selected by Head Teachers and Medical Inspectors. Submitted to Medical Officer of Mentally Defective Schools.	1. Knowledge of letters or the simplest words. 2. Simple numerical processes. 3. Recognition of subjects of simple pictures. 4. Number and name of brothers and sisters. 5. Differentiation of everyday coins and of colours. 6. Number and order of the days of the week. 7. Familiarity with some well known local matters.	No; demeanour, especially lack of concentration and attention, counts for much.	Imperfect response to several of the above tests.	Generally, work systematically through above.	Inspection twice a year; fuller examination of children specially noted by Head of Defective School.	Grouping in classes, according to mental defect.	Yes, such factors often show that the child is dull or backward, rather than defective.	Special examination of those a. who seem too bad to remain. b. who seem to have a chance of holding their own in an ordinary school.	Confirmed epileptics, even if sane, are not admitted. Yes.
O	a. By teachers after examination by Committee's Inspector. b. By Assistant School Medical Officer.	a. Children tested in reading, writing, dictation, number, description, answering easy questions. b. Physical examination of eyes and ears. c. Inquiries as to home conditions.	No.	—	—	—	No, according to ability in occupations.	Yes, always.	a. Satisfactory work. b. Incapable of receiving benefit from further instruction.	No. Yes.
P	Selected— a. By H.T.'s. b. During medical inspection.	a. General appearance, stigmata, muscular tone, and co-ordination, gait. b. Speech, general knowledge, observation and attention, ability to carry out simple actions involving judgment, memory, &c.	Binet's tests applied, but not rigorously.	—	—	By comparison of educational attainment, gait, speech, &c., with previous examinations of these.	No, according to educational attainment.	Yes.	a. Unimprovable. b. Occasionally, if defect is slight. c. Others remain in school until age of sixteen.	One epileptic boarded out at a special school. Committee in process of formation.
Q	a. Reports of School Medical Officers, checked by teachers. b. Selected by H.T.'s. c. Reported by parents. d. Reported by Attendance Officers.	Sensitiveness to stimulation. Attention. Memory. Reasoning. Morals (from friends and teachers). Muscular co-ordination. Physical condition. (Classification of Royal College of Physicians.)	No.	—	—	By tests mentioned in Q. 2.	See replies to Question 6 on the schedules filled in by the Head Mistresses.	Yes, all these factors are considered.	Each child carefully examined and record form considered.	No; there are a few mild cases of epilepsy in the Special school. Yes; an After-Care Committee is attached to each Special school.
S	After reference by Assistant Medical Officers, Head Teachers, Attendance Officers, &c.	a. Forms filled up by Head Teacher. b. Children tested in regard to 1. Observation. 2. Intelligent memory. 3. Attention. 4. Mental peculiarities, stability, &c. 5. Number. 6. Speech. 7. Habits. 8. Three R's. 9. Manual dexterity.	No.	—	Many adapted to various types have been evolved and collected from various sources.	By comparing what they can do at a subsequent examination and by teacher's records.	All so classified, but impracticable to keep them separate in schools.	As a matter of routine.	Possibility of further progress, nature of employment offered, home conditions and child's influence on others.	Residential school for sane epileptics. No After-Care Committee.

------ Shows the ages of the children now in defective schools. (Q. 1.)

.... Shows the ages of admission of children now in these schools. (Q. 2.)



B. London Schools.

At this age a number of the boys are transferred to the elder special schools. The figures for these schools are included in both curves.

	3. No. of Classes	4. Basis of Classification and Promotion	5. Children returned to Ordinary School
A	Lowest, middle and upper.	*a.* Attainments on entering Special school as judged from previous teacher's report, and the child's power to apply itself to any simple occupation. *b.* Promotion determined on progress shown from a mental, physical, and moral standpoint (half-yearly report).	None.
Bi	Five.	*a.* General intelligence. *b.* Improvement in two subjects.	Repeatedly. Last year, ten. This year, eight.
Bii	Four.	*a.* Mental capacity of child. *b.* Promotion according to mental development of child.	Yes; twenty-five, an average of 2·5 yearly.
Biii	Two.	Classified according to mental capacity. Promotion by mental development.	Yes; five.
C	Three.	Morning classes classified according to educational abilities; afternoon classes according to ability in manual work.	Yes; thirty-two (including four transferred to P.D. school).
D	Two for most subjects.	According to abilities in three R's and handwork. Classified as 'younger' and 'older,' but individuals occasionally considered.	Yes; one.

6. Psychological or other Classification	7. No. of Children who reach Standard II Proficiency	8. Time for Manual Work. Nature and Organisation of
Each child studied separately : 1. Obedience to commands. 2. Response. 3. Will power. 4. Memory. 5. Moral propensities. Lack of self-control often noticed.	Reading — not more than 40 per cent. Calculation—not more than 20 per cent. Writing — not more than 60 per cent.	8 hr. 20 min. *plus* 1 hr. drawing. Lower classes—Kindergarten. Upper classes—Woodwork, gardening, laundry, cookery, needlework, rugwork, &c. Partly into relation with work of schoolroom, woodwork, and cookery taken at centres.
Beyond a certain point too tedious. Defective speech together for speech training. In the case of those whose reason is undeveloped, begin with little that is known.	Perhaps 5 per cent.	8 hr. Training for the time when they leave school. Taken in relation with ordinary work, most of occupations taken in conjunction with three R's.
This impossible owing to individual differences. Each child carefully studied and taught, according to mental status and moral standard.	Sixteen per cent.	6½ hr. Woodwork, fretwork, basket weaving, clay and paper modelling, paper folding, bead-work, cookery, knitting, and brick building. Yes, brought into relation.
Individual instruction according to child's capacity and needs. One case of cruelty treated for a year.	It is probably possible to secure 25 per cent. at this particular centre.	12 hr. Laundry work, cooking, wood-work, and manual training as distinct from the kindergarten. Hand-training as a part of the ordinary routine. Woodwork by a Technical Instructor at the Technical Centre.
No complete classification. Audiles, visuals, and speech defectives treated individually. Majority seem mentally apathetic rather than definitely deficient in one sense.	About 29 per cent.	6½ hr. ; and for older girls, 8 hr. Kindergarten occupations (cutting and design, bead threading, paper-folding, painting and colour work, &c.), basket-weaving, rug-making, needlework, drawing, chip carving, metal repoussé, cooking and laundrywork. With the exception of cookery and laundry all connected with ordinary class-room work.
Only in a somewhat crude way. (School only opened four years.)	Out of seventeen in school three will eventually be at the level of Standard II.	7 hr. 20 min. More modern kindergarten occupations; cookery, laundry (girls), woodwork (boys), gardening. Yes, except in the case of cookery and laundry.

	3. No. of Classes	4. Basis of Classification and Promotion	5. Children returned to Ordinary School
F	Two.	Classification according to capability, not age.	Yes; four.
H	Two.	Classification according to capabilities (mental power) as well as attainments. Promotion, when there is distinct advance in mental calibre—occasionally to make room for younger scholars. Individuals considered in each subject.	Yes; three (one of whom afterwards reached Standard VII.).
I	Three. Manual work, sometimes four.	*a.* Classification according to capability for lessons. *b.* Promotion by progress, if accommodation will permit.	Yes; six.
J	Three.	*a.* *Class* 1.—Children who have made no progress in the Elementary school. *Class* 2.—Children withdrawn from Standard I., cannot read, write, or calculate. *Class* 3.—Children promoted from 2. *b.* Promotion according to mental development shown by (i) speech, (ii) habits and emotions, (iii) powers of attention, &c.	No (school open two years).

6. Psychological or other Classification	7. No. of Children who reach Standard II Proficiency	8. Time for Manual Work. Nature and Organisation of
No.	Doubtful if any attain proficiency in all three, though some may attain it in one or two.	7 hr. 40 min. Boys: boot-making, gardening, basket-work, rug-making, knitting, &c. Girls: Cookery, housewifery, needlework, gardening, paper-ball making, &c. Garden and workshops attached to school.
a. Studied chiefly through physical expression; corrective physical exercises given. *b*. Aim at cultivating self-control (by means of work which makes the child feel its own power), and self-assertion (child encouraged to assist others), though sometimes this must be checked (detailed account given).	Out of a class of eighteen, five are equal to Standard III. in reading, and four to Standard II.; four equal to Standard III. in writing. Arithmetic weak, particularly written.	7 hr. 35 min. Kindergarten occupations, knitting, needlework, macramé, rug-work, cane and basket work, chair caning, straw mats, woodwork, bead curtains. On school premises, under ordinary teachers. Articles are made for school use.
No; impossible, owing to smallness of the school.	Only one or two. Eight or nine per cent. in reading (not in spelling), 3 or 4 per cent. in writing and dictation, and 1 or 2 per cent. in arithmetic.	Older boys, 480 min.; older girls, 450 min.; younger children, 430 min. Woodwork, shoe repairing, domestic and cookery, bead-work, basket-work, netting, knitting, sewing, &c. Yes, brought into relation with class-room work.
Differences classified:— 1. Defects in receptive paths of brain—hearing, sight, and touch. 2. Defects in retentive centres of brain—inability to perceive, to retain and associate ideas, and to form judgments. 3. Defects in emissive paths of brain—lack of co-ordination of muscles, shown in gait, speech, &c. Instruction regulated accordingly.	School opened recently.	8 hr. As prescribed by Board of Education Regulations for Younger Children. All connected with ordinary class work.

	3. No. of Classes	4. Basis of Classification and Promotion	5. Children returned to Ordinary School
L	Three.	Attainments (chiefly manual) determine classification.	Yes; eight.
M	Three.	Promotion by proficiency in three R's; but older children usually placed in the first class.	Yes; eight.
Ni	Three.	Classification by proficiency in three R's. Promotion by progress in same.	Only one within last eighteen months.
Nii	Six.	Classification according to elementary work. Children who are better in one subject are allowed to go in a higher class for that subject.	Eleven in eight years.
Oi	Three.	Classification on ability in three R's. Promotion on ability in three R's.	Nine
Oii	Three	According to ability in occupations, general common-sense, and usefulness.	None.

6. Psychological or other Classification	7. No of Children who reach Standard II. Proficiency	8. Time for Manual Work Nature and Organisation of
No (small staff).	Between 4 and 5 per cent; some can read and not write; some of 'dullest' good at mental arithmetic.	7 hr. 50 min. Older boys: gardening, carpentry, rug-making, &c. Older girls: cookery, domestic work, needlework, &c. &c. Younger children: kindergarten; it is the practical basis of all instruction.
No.	Only eight out of seventy-five.	7 hr. Drawing, clay-modelling, brush-work, paper folding and cutting, paper-mat making, rug-work, woodwork, cookery, needlework, knitting. Brought into relation with ordinary work, and under control of H.T.
No.	One per cent.	Younger children, 6¼ hr.; older children, 7½ hr. Preparatory to employment after school age. A good deal also in connection with the elementary work, except woodwork, done in school.
No.	About 2 per cent.	7½ hr. Girls: laundry, cookery, needlework, knitting. Boys: woodwork, boot-mending, basket-making, chair-caning. Both: rugwork, clay-modelling, paper folding, mat-weaving. Connected with ordinary class work. Elementary taught by means of manual.
None.	Very few.	Older children, 8 hr.: younger children, 6 hr. Boys: woodwork, chip carving, cobbling, rug-making. Girls: needlework, housewifery, cookery, &c. Yes, except older boys' woodwork, and older girls' cookery.
a. Extremely dull, inert cases—occupations require manual work. *b.* Nervous cases—more sedentary employment. *c.* Moral cases—almost entirely manual work.	About 3 per cent.	10 hr. Boot-repairing, wood-carving, gardening, cookery, housewifery, needlework, rug-making, modelling Yes.

	3. No of Classes	4. Basis of Classification and Promotion	5. Children returned to Ordinary School
Oiii	Three.	Classification according to ability in manual.	Ten.
P	Two.	Classification according to reading and writing; reclassified for special subjects. Promotion in each subject according to progress.	Fifteen.
Qi	Four.	Promotion according to bi-yearly examination.	Twelve.
Qii	Seven.	*a.* Mental attainments. *b.* Improved general response and educational progress.	Twelve.
Qiii	Five (smaller divisions for manual).	*a.* Mental ability and reading. *b.* Progress.	Five.

6. Psychological or other Classification	7. No. of Children who reach Standard II Proficiency	8. Time for Manual Work. Nature and Organisation of
To a certain extent, followed by individual treatment.	Not more than 5 per cent.	Older, 7 hr. 5 min.; younger, 6 hr. Older girls: needlework, cookery, housewifery, drawing. Older boys: drawing, gardening, woodwork, cobbling, rug-making, cane-weaving, paper-modelling. Younger children: needlework, kindergarten. Yes, except cookery and woodwork.
No; special forms of defect receive individual attention.	About 50 per cent. at the age of sixteen.	6¼ hr. per week. Older girls, 8¾: cookery, laundry, dressmaking. Older boys, 6¾: woodwork, weaving in basket, cane, raffia, string, wool, paper. Younger children: kindergarten operations. Correlated as far as possible.
1. Neurotic children— *a.* 'Nervous'—gentle discipline and kindly encouragement. *b.* Neurotic—plenty of work, especially manual. 2. Apathetic children—rousing, stimulating training; drill and lessons needing activity (*e.g.*, 'shop lessons').	Not more than 7 per cent.	10 hr. Occupations according to the Code. Yes, except cookery, laundry, and part of wood and tailoring work.
Teacher makes individual study of each child.	Not more than 10 per cent.; rarely that a child is satisfactory in all three.	Half-time to older children; 6 hr. to younger. Older boys: tailoring, woodwork, shoemaking. Older girls: domestic training. Younger children: kindergarten occupations. Yes, as far as possible, all the work under the control of Head Teacher.
Classification indicated by S.M.O. Special classification for the word-blind and those who cannot understand number.	About 11 per cent. Many attain the standard in reading, but not in number or composition.	Half-time. Older children: industrial work. Younger children: kindergarten. Yes.

	3. No. of Classes	4. Basis of Classification and Promotion	5. Children returned to Ordinary School
Qiv	Five.	*a.* General ability. *b.* Progress.	Ten.
Qv	Five for elementary work; seven for manual work.	Classification and promotion based on proficiency in the elementary subjects—particularly reading.	None.
Ri	Six.	Classification according to capacity. Promotion on attainments.	Eleven (since 1899).
Rii	Six	Ability. No 'record form.' Progress books kept by teachers.	Nine.
Riii	Three.	1. Mental capacity. 2. Physical capabilities. Children in each class divided into older and younger, according to mental attainments; work graded accordingly (details given).	Two.
Riv	Three.	Classification based on mental capacity and physical defects. Promotion by progress.	Eleven.

6. Psychological or other Classification	7. No of Children who reach Standard II Proficiency	8. Time for Manual Work. Nature and Organisation of
1. Undeveloped mental powers— *a*. Removal of cause (*e.g.*, adenoids). *b*. Food, exercises, simple lessons. 2. Abnormal cases—special attention to manual work. 3. Morally defective—bad habits checked; training by lessons and example.	About 11 per cent.	Half-time with older children; a little more with younger. Older children: industrial work. Younger children: work preparatory to the older occupations. Except woodwork, taught in school.
Defect judged by S.M.O.— 1. Word-blind—reading replaced by manual work. 2. Number-blind—number omitted.	About 13 per cent.	7½ hr., upper classes; 6 hr. 40 min., lower classes. Industrial work for boys. Domestic training for girls. Younger children: kindergarten, rug-making, &c. Yes.
No; classes too large, staff too small and not qualified for such work. Epileptics are isolated.	Eleven in twelve years. Upper children still deficient in some of the three R's.	7½ hr. Boys: woodwork, metal-work, netting, cardboard modelling. Girls: housewifery, laundry, cookery, and needlework. Yes.
No.	Almost *nil*.	12 hr. Tailoring, housewifery (and cooking), hand and eye, plain needlework. Yes.
Impossible, owing to large classes (twenty-five to thirty).	About 2 per cent.	6 hr. 40 min. Tailoring, housewifery, strip-work, needlework, rug-making, raffia work, flower-making, netting, kindergarten. Yes. (Record Form under 4.)
Practically none, but low-grade cases placed in lowest class.	About one-ninth (11 per cent.)	Class 1, 6 hr. 15 min.; Class 2, 8 hr. 45 min.; Class 3, 6 hr. 5 min. Boys: tailoring, gardening, netting, cane-work, wire-work, clay-modelling, drawing, kindergarten. Girls: needlework, macramé, kindergarten, clay-modelling, paper-flower-making, drawing, rug-making, housewifery, cookery. Yes. (Record Form under Question 4.)

	3. No. of Classes	4. Basis of Classification and Promotion	5. Children returned to Ordinary School
Rv	Six.	Classification—general intelligence. Promotion — *a.* Incapable of progress—put in manual class. *b.* Others promoted according to mental improvement.	Fourteen.
Rvi	Six (including workshop and kitchen classes).	*1st class.*— Older children—half-time manual and half-time class instruction. *2nd class.*—Young children who show improvement—ordinary school work and occupations. *3rd class.*—Trial class for newcomers. *4th class.*—Bad cases. Promotion according to capability.	Eighteen.
Si	Five.	'General common-sense' and manual work. Promotion as vacancies occur in upper classes.	One.
Sii	Seven.	Cross-classification according to subjects.	None.
Siii	Six.	As in Standard II., with exceptions for special occasions (*e.g.*, moral).	None.
Siv	—	As in Standard III.	None.

6. Psychological or other Classification	7. No. of Children who reach Standard II. Proficiency	8. Time for Manual Work. Nature and Organisation of
	Eight per cent.	8 hr. Carpentry, ironwork, clay-modelling, boot-repairing; housewifery, cookery, needlework, kindergarten. Yes.
No; teachers guided by experience alone.	Reading and spelling—about 40 per cent. Arithmetic—none reach Standard II. level, except with regard to knowledge of money value.	Older children, 10 hr.; younger children, 7½ hr. Yes, conducted on premises under control of H.T.
Individuals are studied and treated as needs require.	In ordinary sense of words, very few. All energy bent on giving practical acquaintance with these subjects in connection with manual work only.	7½ hr. to manual work proper, but all lessons taught through hand. All of it is in close relation with school work, and under H.T.'s control.
Children are studied and characteristics are noted by teachers.	A very small percentage, but present progress encourages hope for better results in future.	7 hr. definitely, but manual methods constantly in use. Under H.T.'s control, and in close relation to ordinary work
As in Sii.	Fifteen per cent. in reading, but in other subjects none.	6 hr. 40 min. Very varied. Under H.T.'s control, and done in class-rooms by ordinary teachers.
As in Sii.	Four per cent. in reading. Four per cent. in writing.	As in Siii. As in Siii.

London Special Schools.

(Summarised returns from eighty headmistresses.)

For questions 1 and 2 see page 181.

Question 3.—There is considerable variation between a minimum of two and a maximum of twelve (this for manual work). Occasionally there appears to be an increased number of classes for manual work, but this is rare. Fairly frequently, too, there is cross-classification for various subjects.

Question 4.—(*a*) In the majority of cases the basis of classification is the three R's, though 'general intelligence' is preferred in a good number of cases. Reading[1] alone is taken in a few cases, and Reading and Calculation in several. Manual ability, age, interest, physical condition, and other factors are also mentioned, generally as taken in conjunction with the three R's or 'general intelligence'.

(*b*) Promotion is generally determined by progress in the above subjects. Many returns draw attention to the fact that promotion can only take place as vacancies occur.

Question 5.—The replies to this question do not admit of statistical summary, since such factors as the length of time during which the school has been opened cannot be allowed for. In the case of four returns it has been possible to calculate the percentage of children returning each year to the normal schools, and this is found to range between seven and twelve.

Question 6.—In the majority of cases there appears to be no psychological classification, one reason given being that these children show too great a variety in their mental constitution to admit of a workable system of classification. It is very generally stated that each child is considered individually.

In those cases where a psychological classification is attempted, the systems adopted seem to fall under three heads:—

A. From point of view of energy displayed by the child:—
   1. Nervous, excitable children.
   2. Apathetic.

B. From medical point of view:—
   1. Hydrocephalic.
   2. Microcephalic.
   3. Epileptic.
   4. Mongols.
   5. Cretins, &c.

C. From point of view of function affected:—
   1. Weak will.
   2. Wavering attention.
   3. Small relativeness.
   4. Lack of co-ordination.
   5. Lack of imagination, &c.

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[1] One return states that Reading is taken as the basis, 'being a subject which needs more collective teaching (than Arithmetic).'

The opinion is pretty generally expressed that it is advisable to separate children of similar defects.

Question 7.—The replies to this range from 'none' to 'all.'

1. All except those irregular in attendance and imbeciles are expected to reach this standard.
2. None—children may improve greatly, but, as a rule, there is always one weak subject; should they reach the required standard they perform with difficulty what a normal child does with ease.

The mean is apparently about 30 per cent., but there is too much variation to admit any importance to this figure.

One return draws attention to the fact that there is a variation from year to year of some 30 per cent.

Another says that only those children admitted at an early age attain the required standard.

In the few cases where separate returns are given for each subject there is considerable diversity of opinion as to the relative difficulty of the three subjects. A few returns show that in the case of Arithmetic and Writing the percentage varies according to what the subject is meant to include, thus:—

(1) Arithmetic, on paper, nil; mental, 30 to 40 per cent.—problems are very difficult.
(2) Writing, 80 per cent., or, including Dictation, 10 per cent.
(3) Writing, 90 per cent., or, with Spelling, 50 per cent.

Question 8.—(*a*) Average, from six to eight hours; and, in case of elder boys' schools, half or two-thirds of the total time spent in school.

(*b*) Many forms of handwork are given, from kindergarten and paper-folding to laundry, cookery, and woodwork, bootmaking, and tailoring.

(*c*) With the exception of the domestic subjects and woodwork (and in the elder schools, often these subjects, too), the handwork appears to be under the control of the head teacher of the Special School.

APPENDIX III.

Detailed Report on Methods of Testing Mental Deficiency.

(The Committee is indebted to Dr. Shrubsall for this Report.)

The methods employed in arriving at a diagnosis involve medical, psychological, and pedagogical elements. It is not possible to draw a hard and fast line between these, and it will probably be clearer to describe the examination without at first distinguishing between the elements.

Before the child is seen by the medical officer a nomination form is usually filled up by the teacher of the school, if any, the child has attended. In the case of children nominated by the Attendance Officers' Departments, there is usually no information at all available.

The first items, name, age, and address, call for no comment;

the time the child has attended school is valuable as giving information bearing on possible backwardness. Most teachers here enter the regularity of attendance, and any information they may possess as to the causes of any absences of note. As every child is seen by the medical officer, item 5, asking whether the appearance of the child is stupid or bright, throws more light on the teacher's personal equation or powers of observation than on the child's mental condition, though it might be useful if any cases were rejected at the nomination stage. Information as to whether the child is obedient, mischievous, or spiteful is valuable, especially the first and last points. Most children seem to be entered as either apathetic or mischievous. Spitefulness is often mentioned, sometimes on the authority of the parent, but sometimes, and this is of value, because of complaints lodged at the school of the child's behaviour in the street. Spitefulness appears to be more common in low-grade educable defectives and in imbeciles, but also markedly occurs in a group which will demand separate attention—the a-moral children. Question 7, on the habits of the child, is essential, since one who has not acquired the first elements of cleanly behaviour, even in respect to the excreta, cannot be tolerated in any school even if there are difficulties in the way of immediate classification as an imbecile. It is sometimes sufficient to invalid these children for six months or a year, making the parents fully understand the obstacles to formal education. It is remarkable that a number of parents are quite careless in respect to this primary education in habits until it is forced on them by the inconvenience of having a child at home when they wish to be rid of him during school hours. It might also be noted that these children when not complete imbeciles are almost always, in my experience, of the male sex. The information derived from item 8, as to any peculiar or dangerous propensities, usually only leads to a repetition of (6) 3 as to spitefulness, but occasionally some information as to particular misdeeds is given. Question 9, asking for direct information as to the teacher's estimate of capacity along certain lines, is most valuable as an estimate of the standard of the school or of the teacher, and after a sufficient number of forms from one school have been studied it becomes a great aid in regard to the chance a child would have in the said elementary school after discharge from a special school. In spite of the abolition of payment by results there is still in many schools a certain standard which is looked on as the irreducible minimum consistent with being a reasonable soul, and if the school has a good scholarship record this minimum in no wise coincides with even the mean standard intelligence of the merely backward group of children. Where differences between the medical officer's estimate and that of the teacher occur, the children should be submitted to a psychological investigation by the more recent experimental methods. Teachers sometimes fail to realise the importance of the questions under this heading, and this is to be regretted, as during the time in the infant school or in the standard opportunities must have occurred of testing all the points under far more favourable conditions than arise at an admission examination, where the work must be done rapidly, and the confidence of the child may not be thoroughly

established even when the class teacher is also present. *A priori* the results of an admission examination should be below the teacher's estimate; in practice the reverse happens in a large proportion of cases, especially when the child comes from a senior department. Notes on observation, imitation, and special tastes are conspicuous by their absence; attention and memory are usually described in negative terms; reading, writing, and calculation as Standard O.

It is only right to say that there are many exceptions in which most accurate and valuable information is afforded, and the deficiency in others is doubtless to be attributed to a failure to recognise the real value of the information on the schedule as a corrective to the direct observations and conclusions of the medical officer.

The question as to whether a child is affectionate elicits little information, and again is confused with spitefulness. Question 11 is too indefinite, but may elicit information in regard to any sexual irregularities. The remaining questions need no comment.

The schedule is of value in giving some indications of the line of inquiry to pursue, but does not fulfil expectations. As time goes on the value will probably increase, particularly when head masters and mistresses have closer acquaintance with modern methods of psychological diagnosis.

At the time of the examination the child attends accompanied by his parents, if they choose, and by the class teacher, when possible. The examination usually begins by inquiries addressed to the parent as to the general state of health of the child, his conduct, and any points to which she may draw attention. The results when to the point are entered in a special record-book, but the real object is to enable the child to become accustomed to the room and to enable observations to be made as to his behaviour and general carriage.

The child may be restless or apathetic, his attention may be given to some object in the room, he may start playing on the floor, pick restlessly at objects, or even take up and begin to destroy some object which attracts his attention. On the other hand, many are shy and cling to their parents.

The child is spoken to and asked his or her name, and the attention attracted if possible by something such as a picture-book. The order of the succeeding tests and those employed must depend on the response obtained and the willingness displayed. The less ready the response, the more the early stages must be made attractive or even to resemble a game. The tests cover such medical observations as may explain any deficiency or backwardness, including rough tests of the acuity of the senses, muscular control, carriage, presence of adenoids, and, if necessary, a more complete examination of the body generally. The tests which might be classed as psychological cover spontaneity, motor and sensory response, immediate and remote memory, will-power, as shown perhaps with memory in responding to a series of commands. Finally, partly pedagogical and partly psychological tests in relation to reading, writing, and calculation.

Medical tests or observation.—General aspects; whether undergrown or otherwise.

Form and size of the head.—Microcephaly, oxycephaly, rickets, hydrocephalus, marked asymmetry, &c. It seems impossible to lay any stress on the diameters, the variation is as great in normal children, *pace* certain observers.

Shape of the face.—Features normal or coarse. Shape of the nose, whether a good bridge or sunken, small or large orifices, incidentally evidences of catarrh or rhinitis. Changefulness or fixity of expression. Overaction of frontal and facial muscles, coarse or fine. Presence of epicanthic fold. Knitting of eyebrows, grinning, &c. Power of fixation with eyes and eye movement, squint, &c. Movement of head instead of eyes in following an object moved a short distance. Defects in these respects may lead to backwardness from inability to fix attention, or inversely may be the sign of a mobile attention. Shape of the ear, of the palate, and tongue. Dribbling. While irregularities in shape, size, &c., accompany mental defects, they are not pathognomonic—defective movements are more important.

The movements and attitude of the child are noted, erect carriage being as a rule better than slackness. The way in which the hand is held is recorded, but the nervous pose is far more common than mental deficiency. A far more important point is to note whether a child having been asked to do something, say hold out his hand or open his mouth, will leave his hand in position or remain with his mouth open while his attention is directed elsewhere. This is usually a sign of deficiency at the age of six onwards, but errors can arise, as the child may have the drill-lesson so impressed on his mind that he will wait in any prescribed position until ordered to assume some other. In a certain number of children at this stage the power of touching the nose with the finger from the horizontally stretched position of the arm as a starting-point may be tested *with the eyes shut.* This tests both motor co-ordination, muscular or position sense, and the will-power, both to execute the movement and to keep the eyes shut. A preliminary failure may occur through suspicion on the child's part as to what is to happen while the eyes are shut. It is unfortunate that the parents and sometimes the teacher tell the child they are to see the doctor and constantly refer to the examiner as doctor before the child. If the child has recollections of uncomfortable episodes associated with doctors confidence is hard to establish, though its absence is a test of memory and sometimes may be utilised to obtain evidence of descriptive power by asking the child why he dislikes doctors.

At this stage certain defects, as chorea, hemiplegia, various paralyses or ataxia are noted down, though they would really have been noted before much of the foregoing. At this stage, too, the power of imitation is tested in doubtful cases. The movements to be followed may, if desired, begin with fine movements as of the fingers, and if these fail the larger arm or trunk movements attempted. It is better in a case of suspicion to commence with a massive movement as picking up some object, then to try arm and leg movements, finishing off with the fingers. It does not take long, and in cases with a rapid response several stages can be omitted. Any additional movements should be

noted, the most common being overaction of the facial muscles. Incidentally by this time some information as to the child's hearing powers, grasp of new ideas, and speed and range of response will have been obtained.

A child of seven to eight or over who cannot or will not imitate may provisionally be regarded as below the ordinary elementary school level. It is perhaps necessary to go into the question of will, in the sense of a strong will not to do anything, but some indication of this will have been obtained from the child's demeanour.

In the case of a child who failed to imitate, one would have had some indication as to how far, if at all, his attention had been fixed, by watching the movements and listening to the instructions. Further tests might be made in such a case by the use of various objects, coloured balls, spelicans, a pocket knife, or as a supreme test a penny. If these fail to attract attention the child may be either invalided or excluded as, for the time being at any rate, ineducable, and if there is satisfactory evidence from the demeanour and history of lack of attention he may be classed as imbecile, especially if the inattention extends to matters of common cleanliness. If some attention is paid, the child may be tested with other simple movements, as folding a piece of paper, turning over a picture-book, &c., or by asking him to sit down or open the door. With no response the child may be regarded as below the special school level; with a response the history needs to be gone into to determine what opportunities the child has had, but at the best such a one would be admitted on probation. These cases are revised within three months of admission to a London special school, and in times of great pressure if the home circumstances were fair the child might be left at home for six months and then re-examined.

Throughout it is most important to note all evidences of spontaneity—there is no worse sign than a child doing nothing at all. The child whose imitative response had been adequate would be asked to perform certain well-known movements, such as sitting down, opening the door, &c. Here it is as easy to, at the same time, test certain features of attention and memory by asking for the performance in a specified order of several separate actions. Thus: 'Put on your hat'; 'Take a pencil from the table and put it on the form outside'; 'Come back and mind to shut the door after you.' A child who performs all in the right order after being told once possesses a considerable basis of power on which the teacher could build, and a close examination would be necessitated in order to determine that he was deficient and not merely backward. Most, however, fail to carry out more than two commands. A usual result is for the child to put on his hat, go outside, and have to be fetched back. Normal eight-year-olds in Standard II. do all without hesitation.

The examination may next be extended to the nature and use of well-known objects. Suitable ones are a key, a knife, coins, &c., and the statements of what a child would do with them are of great value. The knife is practically always known and the key usually, the coins depend on the value. The children at this age rarely have experience in actual life of anything above sixpence or of personal

possession above a penny.[1] Though coins are taught in the infant school, the impression is less real and vivid. With older children it is well to know what they do outside of school, as some who sell newspapers, &c., have a much greater acquaintance with coins than others.

Pictures give some interesting results. At admission examinations it is sometimes difficult to get a response without pointing to the object in the picture required—many children insist on saying 'pitty picsher' instead of mentioning what it represents. The response, when obtained, usually consists of nouns used as interjections, and given forth with considerable vehemence in the delight of new discovery, *e.g.*, cat, dog, horse, &c. In this test some care is needed to be sure the child might reasonably be acquainted with the object. Children have been found who had never seen a cat or a picture of one, and if a cat is not an object of common knowledge, how much must one guard against inferences from failure to recognise other animals. The human figure, cats, dogs, and horses are usually recognised, though the latter may be called a cow. Sheep, pigs, and goats are less well known. Sometimes success follows an elephant, tiger, camel, or rhinoceros when a sheep is unknown. This is due to pictures in infants' rooms or a school visit to the Zoo—an impressive event. Birds are usually called 'bird' without distinction of kind even in Standard I. of the Elementary schools. With defectives at this stage of their education descriptive or qualifying adjectives are extremely rare, and often not more than one noun per picture can be elicited.

The powers of observation and also probably memory can be tested by asking, 'What did you have for breakfast?' 'What did you see on your way to school?' &c. A poor response is obtained in seven- and eight-year-olds suitable for special schools. A good response leads ultimately to more detailed inquiries into possible causes of backwardness.

Tests of general knowledge such as 'What pulls a cart?' 'What street do you live in?' 'Where do the trams go?' &c., are often necessary and useful. The best response is to the second query, since even defective children usually have their address drilled into them by their parents in case they should get lost in the streets. Still corresponding children in the ordinary school answer these immediately, the defectives slowly. With these can come simple associations of number and powers of addition and subtraction set, not as propositions but as corollaries. Thus: 'How old are you?' 'How old will you be in two years' time?' 'How old were you two years ago?' 'What day of the week is it?' 'What is the day after to-morrow?' 'What was the day before yesterday?' &c. Dr. Hogarth has described a method of marking the answers in No. 5 of School Hygiene: he gives one mark for the present age, two for age last year, next year, and the year after,

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[1] If as a question in a formal series a child were asked 'Would you rather have a penny or a sixpence?' it is well to remember an answer 'a penny' does not mean necessarily it does not know the difference in value, but rather that it is aware the mother would take away the sixpence.

three for an answer dealing with a three-year period, and four for one who can at once say his age in, say, nine years. Similarly with the days of the week. Four for an immediate response, three if prompting is required such as not to-morrow but the day after. Most can only answer the primary question, 'What day is to-day?' by the help of prompting, as 'Is it Sunday?' An answer then gets one mark, but by afterwards giving to-morrow and yesterday two can be obtained.

Dr. Hogarth follows this test by asking, 'What is a cat?' His marking being—

1. No response. If the child's confidence has been gained it is then probably defective.
2. It's a kitten, it's a pussy, or it's a cat—One mark.
3. What catches mice, &c.—Two marks. This is the average answer of a dull or backward child over seven, and of some of the less severe cases of general mental deficiency.
4. A cat has four legs, &c.—Three marks. The answer of an average child of seven to eight.
5. A cat is an animal—Four marks.
6. A cat is an animal with four legs and a fur coat—Five marks.

Only bright intelligent children give such answers. Three, four, and five marks on these scales show a considerable degree of intelligence.

The children with one and two marks are further asked 'Have you a pussy-cat at home?' 'Have you ever seen a cat?' &c. Or to test the number of ideas, 'What does a cat do?' As a last resort, Dr. Hogarth tries 'What would it do if you pulled its tail?' He says this always produces some such response as 'scratch' or 'bite.'

For older children at the leaving stage similar methods can be used with harder subjects, as steam-engines, motors, &c., paying attention to the boys' opportunities for knowledge. Still this test alone will not suffice, for a boy may know some subject well and yet be unable to do any form of school-work. It is not sufficient to test the intelligence only without relation to school-work.

In some cases the colour sense would be tested both as to the power of naming simple colours and of matching simple colours. There are a good many children who will match reasonably correctly and yet make some extraordinary efforts at nomenclature. Generally, however, a child of seven to eight years in the Elementary schools should be able to name red, yellow, green, blue, brown, black, and white, which are the ones employed. Some children up for the examination may only know, say, red in addition to black and white. All who respond at all to questions know black and white. Most of the children who failed to give names of colours correctly match them passably and do not make the classical errors in matching. If anything, the tendency in naming seemed to be to put deep yellows with red, and greens with blues, under either name. This is a phase passed through in the infants' school some two or three years earlier with the majority of normal children.

The tests of educational acquirements or powers of production are, with the present arrangements of schools and curricula, forced to play an important part in the inquiry. Roughly, these are confined to the

three R's, but an endeavour should be made to distinguish between pure mechanical performance and intelligent use.

The three R's may be taken separately or together; with an older or more intelligent-looking child I like the combined methods. Thus, show the child a paper on which is typed or written 'Pick up a pen and write your name.' If this is done, the power of intelligent reading is established. Or end up with 'Write down what is in the fire.' A response shows the power of spontaneous writing, and if such a child can do some reasonable calculation no question of deficiency arises. Indeed even if the calculation failed, but the child could count, much evidence would be necessary to show that it is more than backward. However, with the bulk of the children seen at admission examinations no such short cuts can be employed.

Reading.

It is necessary to have several grades and varieties of reading-books, as a certain initial shyness may prevent a child making an effort with a book which has a different type from that to which he is accustomed. Children say, 'We don't have this book at our school.' However, with the help of the teacher from the school in question a suitable book may be chosen, and the child is shown a simple sentence and asked to start reading. I generally choose three- and four-letter words—*e.g.*, the cat was on the mat, &c. If this is read satisfactorily I ask the child to show me a mat (if there is one in the room), or the cat (if a picture of one is available). This being done correctly, harder sentences in this or other readers are found until the child's limit as to (*a*) mechanical and (*b*) intelligent reading have been determined. The results are entered as Grade I., II., III., or Standard I., II., &c., as the case may be, corresponding to the level of these classes in the average Elementary school. Should the child not start to read, it may be shown some little words and asked to read them, is, it, was, on, no, &c., being useful. Or the child may be shown the picture in the reader of a cat, dog, cow, &c., and asked to point out the word on the page. It is well to note all instances of reversal, thus, *on* called *no*, &c., for they are fairly common. They represent a common phase in the lower grades of infants' schools, but should have been dropped entirely by the age of eight. To connect the mechanical process of reading with an understanding of what is read is most important, and in this connection an examination of, say, twenty children from some two or three schools throws light on the teaching methods even more than on the attainments of the individual children.

It is well to get the child to spell out a word or two, as quite a number know words while only knowing a few letters. I feel convinced that the bulk of children in the schools learn each word initially, if not permanently, as individual ideographs, and that the process of learning to spell them afterwards is slow and painful. For this reason, if a child has been referred back to the infants' school for, say, six months, and then comes up for re-examination, it is well to adopt a somewhat different order and method on the second occasion, for an observant parent—and there are some such, even of defective children—

may have noted the sentences used in the methods previously referred to and specially taught these to the child. It is also necessary to bear in mind that a child may be able to read only small letters or only capitals, or *vice versa*; that he may or may not know anything of cursive script. In cases of doubt, when using the sentence methods, the teacher from the child's school should write the sentence in the way usually adopted at school.

Certain other points crop up and may be recorded in regard to reading. There is the impressionist child who, seeing two letters, builds a word and reads away apparently fluently, but if you chance to be watching the passage, often inaccurately. There is a similar type who will take a book and at once begin to read, but not a word that the child says may be on the page in question; yet such children, usually girls, may appear to read long and reasonably connected sentences. Such children must have good memories of a kind, I should think, with an aural basis. Others spell out words very slowly, obviously gaining the word from the letters. Of such there are two types: those who say out loud or under their breath the letters named as letters, *c-a-t*, and then produce *cat* and those who deal in sounds, *ker-ah-te*, and may also give *cat*. In unusual words both these methods lead to disaster, which should be credited to the system rather than the child. Indeed, one of the great difficulties in assessment, especially for a recently appointed medical officer, is the weight to attach to the effects of different systems of teaching reading. Due allowance must be made for the method used at the school whence the child came. Most stress should be laid on whether the reading is accompanied by any understanding of the subject-matter read. It is often necessary at these admission examinations to enlist the aid of the teacher to get the child to read at all, and in any case the reports of school performance are of great value, particularly in the case of a child who does nothing at the examination. In the rarer case, in which a child said to do nothing at school performs well at the examination, the capacity must be estimated by the better performance, and sometimes a change of school may be advantageously suggested.

Writing.

This, as before mentioned, is tested as to transcription, dictation, and spontaneous writing. It is quite common for it to be said that a child can write, and on investigation for it to turn out that it can *write its name* and nothing else, sometimes not even a component letter. The form of inquiry from the teachers might well be modified so as to cover these points, since the answer too often applies to transcription only.

If a child of seven to eight cannot do transcription, and has received a reasonable amount of instruction, he would be regarded as defective. Dictation reveals several types of defect included generally under the word blindness. In some instances the child may make a little progress in reading, but in writing, although quite able to copy, show by the gibberish put down in dictation that letters are nearly meaningless. On this account it is well to have at the examination a specimen of the child's ordinary school production. The milder grades

of defectives in this respect generally show the influence of associations of sound, and in some cases the reading methods may have been in part to blame. Spontaneous writing is tested by asking the child to write down the names of simple objects held up for him or otherwise indicated. The final test may be to get a child to read, after a brief interval, a word or sentence he has written. If, for example, he had written to dictation 'Pick up your cap,' and he is later shown the sentence and told to do what it says, and does it, the chain of writing connections would seem to be complete, though there is the possibility of the reinforcement of his reading by the aural and motor memories of the preceding stages.

Arithmetic.

The variation in this is so great that no one line of procedure can be suggested. Perhaps the most usual start is to ask some such question as 'What is three and two more?' If this fails, try 'If you had three apples and I gave you two more, how many would you have?' The latter is far more often answered than the former. Similarly with subtraction. These points are often brought out at an earlier stage by the query, 'How old will you be in two years' time?' The knowledge of multiplication may be tested if the child has learnt it at all, but they rarely have attempted anything beyond the six-times table. Even then it is a common experience for a child to know say, all the three-times table if allowed to start at the beginning, but not to have any idea of three times six without saying the table through to that point. However, inquiries into the acquaintance with the table belong far more often to the examinations in the schools with a view to return to the elementary school than to admission examinations. A child who has failed at 3+2 under all mental forms is asked to count them out, using any convenient objects—counters, spelicans, or the fingers. Addition in defective children, if performed at all, almost always involves counting from the beginning, even if only one object has been added to the heap already counted. A certain number cannot count at all; these are reviewed with the special question as to educability in the foreground. A child who has had opportunities of education for some time and who still cannot count, would at the best be admitted to a special school on probation.

Speech.

In the course of the foregoing tests evidence as to speech will have been collected. There are many forms of mis-pronunciation, and only those who cannot be understood at all are necessarily thereby rendered unfit for a special school. Defective speech without other defects (to a marked degree) might qualify for special instruction, or for a stammering class where such exists, rather than a defective school.

General Intellectual Capacity.

In estimating the results of the examination allowance must be made for educational opportunities. This is largely done in the course of inquiries into general knowledge, memory, and power of attending. A child who has not been to school at all, or who has attended but

rarely, cannot be expected to have many educational attainments unless the parents have been able and willing to give some instruction at home. The home atmosphere is very important; where this is bad and the children are never talked to intelligently, little can be expected; but a very backward child in a bright home may, in the absence of special explanations, be regarded as defective. A child of ten or more unfit for Standard I., even if showing some signs of general intelligence, would make more rapid progress after spending a term or two in a special school. Such a child is too old for the infants' school, and does not profit by the large classes and necessary mass methods of the upper departments, but responds well to the more individual methods that are possible when dealing with smaller classes. Many children of the higher grades in special schools might do well in schools of the intermediate or Mannheim type.

Children may be, as a result of this examination, either (1) sent back to elementary school; (2) sent back to the infants' school for a period if their age allows (nine is the limit); (3) certified as mentally deficient; (4) excluded as imbecile or ineducable; (5) invalided for a specified period.

Once admitted to special schools children are re-examined about three months from the date of admission, and thereafter at intervals of from six months to a year. The examiner sees the teachers' reports and the children's exercise books and manual work. The examination in the main is on similar lines to that at admission, but there is more opportunity to go into details or to follow out any particular line of inquiry. In the upper classes of special schools, where all the children (or nearly all) can do some writing, mass methods save time. Paper and pencils are distributed and the children told to write their name at the head of the paper. They are then shown an object or picture and told to write the name. Then to write the answer to some simple question, as 'What does a cat eat?' Then three or four words of dictation. Then to answer a question written on the blackboard, as 'What is in the grate?' Then the answer to the written question, 'What is twice two?' or such like query. Then the answer is to a similar but spoken question. An addition or other sum is then dictated and another written down on the board. When these are finished the children are seen individually. As they come they are handed a slip with such a request as 'Pick up a pen,' and are told to do what it says. A preliminary experiment to explain that this does not mean either reading the sentence aloud or writing it down is often needed, in which case the marking is a point lower than for an immediate response. Then some general questions, including perhaps 'What is the day after to-morrow?'

In general the examination otherwise follows the lines before mentioned, except when any special point is being tested, or when the medical officer is experimenting with some test or other, which would then be tried on all cases, in addition to the usual routine of general knowledge, intelligence of response, attention, and the three R's.

Up to the age of twelve and a half children who would be reasonably able to enter Standard II. are returned to the ordinary

Elementary school; after this age the boys go on to older mentally deficient schools, where there is much manual work and training with a view to special trades, which provide a better education for them than they could have in the ordinary schools. To a lesser degree similar facilities are provided for the girls.

From the start in the special schools half the day is devoted to manual training in some form or other.

In dealing with such special investigations as have been made it would perhaps be easier to follow the lines of some text-book and indicate how far they have been or could be easily tried. For this purpose Whipple's 'Manual of Mental Tests' has been used.

Anthropometric Tests.

These can all be easily taken, and most have been tried on a larger or smaller scale. From the standpoint of diagnosis they are of very little use. Stature and weight can be dismissed at once, though I agree with the conclusion that the defective children are inferior to the average. But so they are in social status, on the average, and if compared with those from corresponding poor districts only there is not much difference. Head dimensions are very variable and only characteristic in extreme forms, when they are often associated with imbecility, *e.g.*, the hydrocephalic or the microcephalic. The results are of pathological rather than educational interest; even marked deformity is sometimes associated with an ordinary degree of intelligent educational performance. Grip, vital capacity, and tests with the ergograph or dynamometer might easily be taken, though they are not usual at present. In the ordinary way it is clear that the attention flags quicker in the special school than in ordinary children and that the children tire more quickly even of a game. The tapping test could be tried, but does not seem to offer much promise of educational results. The principle of beginning with the massive muscles and larger joints is fully realised in the drill, manual training, and even in teaching writing.

The target test for aiming is used as a game, but the results have not, so far as I know, been recorded. The electrical tracing test offers some promise, since it could be used as a game, while at the same time giving a valuable training in muscular co-ordination. For this the bell would be the important part of the apparatus. The same applies to the steadiness tester.

Sensory Capacity.

Visual acuity is tested by Snellen's types if the children know the letters, or by Cohn's E test, and some experiments have been tried with pictures of animals in place of letters. Visual defects are common among mentally defective children and are a source of trouble, in that the glasses have to be prescribed from the retinoscopy alone, while the careless habits of the children lead to frequent damage to the glasses when obtained. To avoid loss they are often kept at school and not allowed to be taken away. Some tests of eye balance have been undertaken. Colour vision is in a sense tested in the course of instruction and the wool tests are sometimes used.

Hearing is tested by the response to the ordinary voice and to the forced whisper at varying distances. The elaborate detail of the psychological laboratory is not possible in the classroom. Some experiments in discrimination of pitch have been made in the case of the deaf and defective, as have some with Galton's whistle. They would not aid in the duties prescribed by the Act.

The discrimination of weight and form, size, &c., is definitely taught in some of the special schools. There can be no doubt that most mentally defective children are behindhand in this respect, but the influence of practice goes a long way. The method might be utilised perhaps with advantage in the later examinations, but save for definite research purposes elaborate method could hardly be adopted. Pain tests are not tried, but a defective child with a broken tooth and exposed pulp has been known to worry very little over it. The difficulty would be to get any results at all. With special care such experiments might be conducted by someone with whom the children were very familiar; *e.g.*, a teacher who had received the necessary training. I should have little doubt that in the defectives it was largely a study of states of attention.

The range of visual attention is only tested in reading, a topic too long to discuss here from the school medical officer's standpoint, though it would be worthy of much attention.

Those who use word-wholes or dominant letters make the most effective 'intelligent' readers; the others spend so long on letters or sounds in various building processes that there is nothing left to understand with.

The spot pattern test might be experimentally tried, though the difficulty would be to get the children to understand what they were to do.

Tests of visual apprehension are now used as a game and as part of the training of boy scouts. The test has been employed at admission examinations using some four or five common articles, but not with success; better results might be got at centre visits. The use of pictures has already been discussed.

Cancellation tests, or the similar underlining test, is recommended by Sherlock for use with mentally deficients. It is useless for admission examinations unless only such a letter as O were chosen, and it takes too long. It seems to offer some promise as a mass test for the highest class or of those proposed to return to the elementary school, but other tests seem to give quicker and equally accurate results.

Dot counting might be tried, but if a child will at an admission examination count correctly twenty large marbles it is all that can be expected from a good-grade defective. Large numbers cannot count to five. We always record gross counting results, and later this, in the form of a rosary, is the basis of a popular way of teaching arithmetic to certain defectives. They get into simpler methods after a time.

Simultaneous disparate activities would, I fear, be beyond use unless sewing and reading were tried with the girls, or knitting. *Description* has been more or less utilised, but it must be verbal unless you have a long time to spare. The higher classes who can write spontaneously

are tried, as part of their education, with easy compositions, which are often descriptive, and from these very useful information may be obtained by the school medical officer, who would naturally look through the books of cases proposed for return to Elementary school or for exemption.

The *Aussage* test could be tried with very long exposures, but as before mentioned it would hardly be possible to get all the questions answered, even if the picture or object were all the time in the sight of the pupil. The same applies to Binet's card of objects; but the method might perhaps be used with advantage in teaching these children.

The *association tests* suggested look promising. In a way they are used, of course, in the line of inquiry involved in the question, 'What is a cat?' previously referred to, but the list method might be tried. They also come in in such questions as 'Is it day or night?' followed by 'How do you know?'

Memory is tested only by the multiplication table and recitations, apart from its obvious bearing on all work. Some can learn little verses quite well. It is the useful forms that always seem wanting. It is tested, too, in questions as to breakfast, things seen on the way to school, &c., but this mixes up with fidelity of report, which is often conspicuously absent. Logical memory is trained in the repetition and explanation of little tales and accounts of current events. Some teachers record impressions on this, but I know of no accurate records or definite investigations. It is a useful accessory, but of less certain direct diagnostic value, save in its misuse, as in the children who will read fluently what is not on the page.

Suggestibility.—See size-weight illusion.

Imagination.—Ink blots as described have not been tried. The children, like others, often add to a blot in an effort to make a picture, but there are no records of results.

Development of sentences.—Used in teaching, and might well be used in examination.

Vocabulary.—Tested in relation to the intelligence of the reading it is clearly very limited, but there are no accessible lists made for this purpose.

Size-weight Illusion.

Demoor's test consists in presenting to the child two objects of identical form and weight but differing in size. To persons of normal intelligence the smaller appears to be the heavier when handled. It is claimed that mentally defective children respond that the larger package is the heavier. Dr. Thomas found in London special schools that the test generally elicited a normal response in the higher grades of children, but the defective response in the lower grades. The test, therefore, divides the defective children in the schools roughly into two classes, one approximating to the dull and backward, the other to the imbecile. He regards it as of considerable value.[*]

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[*] Dr. Myers points out that the 'defect' occurs in *normal* very young children.

Graded Tests for Developmental Diagnosis: de Sanctis' Tests.

The principle employed in these tests has in part been utilised, but not the exact method. In particular the time required for response has not been noted. This applies to all the other tests. One reason is that whilst the child is thinking, the time is used in getting points of history, &c., from parent or teacher, at the admission examinations, or in noting the performance of some other child at a centre. The conditions under which the work must be done require a considerable number to be passed in a short time. This must be borne in mind in evaluating the opinions of the school medical officers. Occasionally there is the opportunity for more. We have, however, no such standard set of objects as de Sanctis suggests to carry about, desirable as it would be from a comparative standpoint; but perhaps some commentary from the methods, having a similar aim, which have gradually grown up in use quite independently of the Italian authority may be pertinent. They will be placed as if for the strict method as narrated by Whipple.

Test 1.—This is tried in almost every low-grade case at an admission examination, and with shy or nervous children generally, as it so resembles a game that a response can usually be obtained. Very few refuse. Of these, some are obstinate and in nearly every case will respond later, if necessary, with the aid of the teacher. The rest turned out to be imbeciles or ineducable.

Test 2.—Tried less often, as, unless distinctly coloured objects are available, it is out of the question. I have tried a similar test showing various objects, including the one the child had previously picked up.

Not having anticipated at any time that I should want to refer in detail to the results obtained by these tests, I find my notes are too brief to allow of an analysis. But I am confident the response was quicker and more accurate when different objects were used than when the recognition depended on colour. Errors in colour certainly arose, particularly between a deep yellow (some might call it an orange) ball and a rather dirty light vermilion ball. The response to this was generally good.

Test 3.—Only tried with a limited range given by wooden bricks, and actually not very often. (I might point out that when a test must statutorily be made on a certain day and time the postulates of the general directions cannot be ensured and the children are not all comparable in the matter of comfort, fatigue, mental attitude towards the test and the observer. This from a diagnostic, as opposed to the experimental psychologist's standpoint, can be reasonably, though not entirely, discounted by appropriate allowances of time, encouragement, &c. Repetition after a day or two is impossible.)

Response is, generally speaking, good even in low-grade cases, who, however, take very much longer and want to stop and play with the bricks instead of finishing collecting those that resemble the one indicated. It gives indications of observation, attention, and perseverance and is very useful, but as time presses it is not used for the better grade of case.

Test 4.—Only tried with letter-cards and pictures of animals as

used in vision testing, &c. Then ask, Show me the E's or the cats, as the case may be. But are these cases comparable?

Test 5.—Tried with bricks or any similar objects of varying size, and without reference to the foregoing. Out of questions asked singly, to elucidate ideas of number, size, and distance, the order of correctness seems ordinarily to be distance, size, and number. But if differences are only slight the estimate of size falls off more than that of distance, both being diminished in accuracy and rate of response very materially, while the estimate of number is unimpaired. The majority of the grade at which this was used touched and counted the objects. There was, unfortunately, no attempt at timing.

Test 6.—These and similar questions seem more adapted to better-grade children. They are useful to detect backwardness, for a child who can answer them at all readily is bright and intelligent or well trained. Now, if a child could answer such questions, yet could not read or write, and had attended school to a reasonable extent, that child must have some specialised defect. If, on the other hand, it had not had any opportunity of education, then it may be expected to progress rapidly and would be regarded as merely backward, because of the comparative rarity of specialised defects associated with a quite bright general response. Such cases do, however, exist; *e.g.*, there is a distinguished draughtsman and inventor who cannot letter his drawings.

The general method of de Sanctis' tests is of high value, especially in dealing with those who cannot read or write, or whose powers in that direction are very limited. Tests 1 to 5 should be passed by the child of seven to eight, as should Tests 6 (*a*) and (*c*). Test (*d*) yields a more doubtful response, as the child hardly grips what is meant, but if time be allowed and the object put in the new position it will be done.

Older children can answer it quickly, but the defectives take much longer. Out of six of these two at least failed.

The Binet-Simon Tests:

1905 Series.

1. Never tried with a match, but frequently by asking child to follow movements of the finger while keeping his head still. Accessory test tried in various forms.

2. Always tested, though not usually with direct intent, but any failure to co-ordinate movements would be noted.

3. As above. Failure with these leads to an examination along physically defective lines—*i.e.*, more strictly medical, with a view to a provisional diagnosis. Invaliding the almost certain result.

4. Tried in so far that the offer of a sweet or a halfpenny is sometimes tried as a last resource with a very low-grade or obstreperous case. Conclusions seem sound.

5. Tried unintentionally, much as described; with a caramel. One unwrapped it, the other threw it at me. The test I have tried is to give the child a simple knot to untie, but not done often enough to have more than the general impression that all but the lower grades attempt it correctly.

6. Always tried. See earlier remarks. A very useful test, as all not defective at seven to eight can pass this. Those that cannot, usually ineducable.

7. Very useful; always directly or indirectly tried, usually the latter. In a definite test on about 400 children in special schools about five per cent. failed to point to their mouths. These were recent admissions in the lower classes.

8. Tried so far as (*a*). See previous note.

9. This does not seem to give the line between idiocy and imbecility at *any* age; 6 is nearer my experience. The question involves a good deal, and the response is by no means always obtained in the lower classes of normal infants' schools. See also the 1908 series.

10. Tried. I agree in the main with the text. I have never used lines of known length.

11. Tried. General agreement as to result. Have never laid stress on it. In asking this and similar questions, or others, echolalia may be noted.

12, 13. Not tried in a reasonably comparable manner. Discrimination of weights is taught in some special schools.

14. See note on 'What is a cat?'

15. Tried. No defective child at an admission examination could do such long sentences, except perhaps (1). I have not used the examples quoted. Yet the child may know a verse of a popular comic song.

16. Tried. Usually looked on as a catch, and so is apt to spoil the examination. Many stick to 'don't know.' I am not sure a response, unless quite to the point, is a good sign.

17-25. Not tried.

26. Tried with older children. More often by listening to the spelling lessons actually in progress. Serve the purpose, but more convenient methods.

27. In some form often tried, especially at later examinations. Questions must not be abstract or the mentally deficient fails.

28. Quite satisfied if a mentally deficient child at later stages can tell the time at all. If a child passed this at admission, should hesitate over saying mentally deficient save for special defect; *e.g.*, word-blindness.

29, 30. Not tried.

1908 SERIES.[4]

Three-year-olds.

1. A little hard for many threes, or even fours, until some time at school. French family life must involve far more talking intelligently to the child—*i.e.*, true education—than obtains in many poor English homes. On this base a general disagreement with Binet's standards as too high in the main; with some exceptions equally too low.

2. Varies. Few will do so long a sentence until some time at school; then they pick up quickly. There are few opportunities of testing children under five in school.

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[4] The comments on defective children refer to those of seven and upwards to fifteen.

3. All who respond could do two at least. I found all the mentally deficients, seven to ten, could do digits, but not always possible to understand what they said.

4. See previous notes. I have never seen a three or four who said 'A man and a dog'; 'Man-dog,' or even 'Man and dog,' I could more easily credit. In saying this I confine myself strictly to the Elementary schools grade of child. Some four-year-olds in good families can and do read the newspaper. (An imbecile might say cat or dog, but would add no descriptive word unless he had had some more definite training than they have usually had when up for report.)

5. I think a three-year-old would give Tommy or Nelly, not the family name. I have tried, but kept no exact records. Five per cent. of the younger mentally deficients, seven to ten, did not know their names.

Four-year-olds.

6. Agree; three per cent. of mentally deficients did not know, and as many said Yes to both 'Are you a little girl?' and 'Are you a little boy?'

7. Agree in the main, but many fours would call any coin 'penny' or 'farden'; all mental deficients who answered recognised and named the objects, though several confused the halfpenny with other coins.

8. Agree; all the mentally deficients passed.

9. Agree; all the mentally deficients passed.

Five-year-olds.

10. Not tried.

11. No certainty as to age level. Tried in mentally deficients *with a pencil*; the upper classes made successful efforts; about half the lower-class children failed. A simple test of manual powers.

13. Fifteen per cent. of the mentally deficients failed to count to five. I have no record of the counting to four correctly but failing at five, but can recall two instances.

Six-year-olds.

14. There are a good many failures at six and over in this. In regard to the feet or turning round any drill mistress could confirm this. The mentally deficients are far behind the normal, but I have no figures.

15. Mentally deficients, or the majority, cannot do it with easier sentences.

17. See previous note on 'What is a cat?' A useful test in good hands.

18. Done earlier than Binet suggests with normal children. Of the mentally deficients almost all failed to carry out more than two of the orders.

19. More than half the younger mentally deficients knew their age.

20. Three-quarters of the younger mentally deficients knew whether it was morning or afternoon.

Seven-year-olds.

21. Not tried.

22. See under *Writing* above. All sevens should be able to do this unless pen and ink have not been allowed, and then pencil could be substituted. At six and a half infants move to senior departments and learn to use ink. Of mentally deficients one-fifth utterly failed, many scrawled, and half were scarcely intelligible.

27. See under 13.

28. Of mentally deficients a quarter failed outright, and another quarter made a mistake.

Eight-year-olds.

29. Much too hard a passage for most eights in elementary schools, but varies directly with the home surroundings. Too hard for most mentally deficients who are leaving. Time certainly longer than given.• An absurd test for imbecility as understood for school purposes.

30. Some younger mentally deficients could count two simple coins; the older ones varied. It is a good differential test of a border case.

31. See previous notes. Most mentally deficients passed.

32. All mentally deficients failed, turning round and going back to twenty at some stage or other. I should not use it as a test; too many normals fail at even older ages.

33. See previous notes. Children of eight can do more than this.

Nine-year-olds.

35. Known earlier, except perhaps (4) the year. Mentally deficients very variable at later stages; beyond them at earlier, *i.e.*, seven to ten.

36. Mechanically in order from Sunday very much earlier. Many passed as mentally deficients could do this. See note on 'What is to-morrow?'

Beyond this point Binet's tests pass out of the mentally deficient range, or my experience. Some, as 47, 49, and 51, could be easily tried but ? diagnostic.

The tests included in this series closely resemble those we actually use; they may test school results more than intelligence, perhaps, as some allege, but that is one factor to be borne in mind in deciding whether a child needs a special school education. The best of them from the school medical officer's standpoint will be included. The real point, I suppose, is whether the series should be used in preference to others. If so, I should not care to give up the three types of writing, the last of which I believe Binet does not include, or the question of response to a written command. The last is very useful, as where present the child does not need special school training in the terms of the Act, excepting a rare condition, as word-deafness, and this needs a modified deaf training.

From the account of the various methods which have been from time to time suggested and tested in the course of examinations, it might appear as if these were lengthy and very detailed inquiries,

lasting, say, three-quarters of an hour each. This is not the case. All the tests are never used at any one time, and eighteen to twenty-two children are supposed to be dealt with in two hours. If one takes a long period, say fifteen to twenty minutes, the time is made up on the others. Most of the points dependent on observation are noted in the course of tests, in which they appear as accidents or necessary concomitants of the action in the test itself. The central feature is to confirm or to controvert the teacher's estimate of backwardness, and if this is present to endeavour to apportion its cause. The distinction required is to divide backwardness from mental causes from backwardness due to lack of opportunities, ill-health, or physical defect, and in particular to arrive at anything remediable. Research into mental conditions is not a primary point, and the opportunities, in point of time, for so doing are distinctly limited. With more time a finer classification might be possible, but this would be of little use without a far more elastic curriculum than at present exists.

The Curricula and Educational Organisation of Industrial and Poor Law Schools, with special reference to Day Industrial Schools.—Interim Report of the Committee, consisting of Mr. W. D. EGGAR *(Chairman)*, Mrs. W. N. SHAW *(Secretary)*, Mr. J. L. HOLLAND, Dr. C. W. KIMMINS, *and* Mr. J. G. LEGGE, *appointed to inquire thereinto.*

THE COMMITTEE was appointed to inquire into the curricula and educational organisation of Industrial and Poor Law schools with special reference to day industrial schools. The terms of reference of the Committee appear to include all such schools in Britain. The certified schools in question fall under two Government departments: the Industrial schools being under the Home Office, and the Poor Law schools under the Local Government Board. There are also a number of uncertified schools of the same kind. It was therefore apparent that three separate inquiries and three reports would be needed.

The Committee commenced work by ascertaining from the Inspector's Report of Certified Industrial Schools for 1909 (the last issued) the number and situation of such schools and the number of their scholars. There are in Britain 77 certified residential schools and ships containing 12,042 boys; and 47 residential schools containing 3,887 girls. There are two mixed residential schools containing 203 boys and 54 girls; and there are 10 short-term residential schools providing for 861 scholars. In addition to these there are 19 day industrial schools with 2,015 boys and 1,220 girls.

In March of the present year a notice appeared in the Press that a Committee had been appointed by the Home Office to inquire into the constitution, management, discipline, and education of reformatory and industrial schools in England and Wales. By the courtesy of Mr. Maxwell (the Secretary to the Home Office Committee) the Committee received a copy of the warrant of appointment of the Home Office Com-

mittee which includes in the inquiry: 'The adequacy of the inspectorate; the relation of the schools to the Education Committees and other local authorities; the qualifications of superintendents and other officers, their remuneration and the practicability of any scheme of superannuation; variation in the types of schools, and whether further provision is necessary for the proper grading of boys and girls; the suitability of ships for use as schools; the preparation given boys for entry into industrial or other careers, and the training and disposal of girls. The care of boys and girls after leaving the schools, and the relation of the schools in this connection to existing institutions for the welfare of young persons; the provision for physical training, recreation, and playtime in the schools; the opportunities for conference and co-operation between managers and officials of the schools; the medical care of the schools; the methods of maintaining discipline and encouraging good conduct, and the extent to which further regulations with regard to punishments are desirable; the relations with parents, and the methods of obtaining payment from them.'

The Report of the Home Office Committee will probably be published in 1912. As the warrant of appointment covered the inquiry contemplated by this Committee, it appeared advisable to delay inquiry into the schools connected with the Home Office until that report is published.

The Home Office Committee, however, deals only with the certified reformatory and industrial schools of England and Wales. The British Association Committee desires to include the uncertified industrial schools.

Of the 77 residential schools for boys cited above 13 schools containing 2,165 boys are in Scotland, and of the 47 residential schools for girls 14 schools containing 1,286 girls are in Scotland. Of the 19 day industrial schools six schools with 644 boys and 412 girls are in Scotland. The reference of the British Association would include an inquiry concerning the uncertified industrial schools of Britain, the industrial schools of Scotland, and the Poor Law schools of Britain.

In addition to the points of inquiry tabulated in the Home Office warrant of appointment this Committee (acting on information received by them but not yet tabulated) would include inquiry into:—

(1) Qualification of school officers.

(2) Grading of children in small schools.

(3) Provision for training in scientific method and logical reasoning, *e.g.*, by simple laboratory work.

(4) Opportunities for developing initiative in both girls and boys.

(5) Medical care of the children and provision for training the children in cleanly habits.

(6) The apportionment of punishment to faults to secure that faults due to environment shall not be punished more heavily than moral delinquencies.

(7) The provision for the training of girls in sewing, cookery, and laundry work by trained teachers of the subjects.

(8) The provision of industrial training for girls in other than domestic matters.

(9) The use to the children in after-life of the industrial training received in the schools.

The British Association Committee ask to be reappointed to inquire into the curricula and domestic and educational arrangements of uncertified reformatory and industrial schools in England, of all reformatory and industrial schools in Scotland, and of Poor Law schools in Britain.

The inquiry is a wide one and will involve some expense in visiting certain of the schools. The Committee therefore ask for a grant of 10*l.* towards the expenses of the inquiry.

The Overlapping between Secondary Education and that of Universities and other places of Higher Education.—Report of the Committee, consisting of Principal H. A. MIERS (*Chairman*), Professor R. A. GREGORY (*Secretary*), Mr. D. BERRIDGE, Mr. C. H. BOTHAMLEY, Miss S. A. BURSTALL, Miss L. J. CLARKE, Miss A. J. COOPER, Miss B. FOXLEY, Principal E. H. GRIFFITHS, *and* Professor A. SMITHELLS, *appointed to inquire into and report thereupon.*

The Committee desires it to be understood that the subjoined statement is an Interim Report only, and is limited to evidence relating to certain types of educational institutions. Further evidence, and the conclusions of the Committee, are reserved for a later Report.

DURING the past few years there have been many complaints of the want of co-ordination between the work of secondary schools and that of universities and other places of higher education. On one side it is stated that secondary schools are encouraged to retain pupils who should be continuing their studies in an institution of university standing, and to present these pupils for such examinations as those of Intermediate Arts or Science of London University. On the other side, it is held that universities and technical institutions are to some extent doing the work of secondary schools by admitting students who are unable to profit by the instruction given and ought to be taking school courses. In an organised educational system this alleged overlapping of educational work would, of course, be avoided. There would be a definite standard of entrance to a university or technical institution, and any work which a pupil at a secondary school might do beyond this standard would be of a supererogatory character carrying with it no additional academic distinction. Our educational institutions have, however, grown up in haphazard fashion without proper interrelationship between them; so it has come about that measured by numbers of successful candidates in university examinations some secondary and technical schools compare favourably with institutions which are ranked as of higher educational standing, while universities and university colleges are holding preparatory classes to enable a certain number of students to pass a qualifying examination, such as that of London matriculation or its equivalent, which ought to be taken from a secondary school.

The present conditions of want of relationship between educational institutions of different grades are natural consequences of the independent growth of these institutions. Much can, of course, be said in favour of autonomy in education, but there is no doubt that it leads in some cases to undesirable competition and dissatisfaction which would be avoided if the work of each type of institution were clearly defined.

It is of interest to record here that in the United States precisely the same situation has arisen as exists in England, and that the latest report (1910) of the Carnegie Foundation for the Advancement of Teaching deals particularly with this subject. The report points out that a great number of colleges are scattered over the United States having no satisfactory relation to the secondary schools from which they draw their students, exacting entrance requirements with little regard to the secondary schools, and receiving in turn from the high schools pupils who are in the majority of cases ill-prepared for college work. The situation, as in England, is unsatisfactory alike to the college and to the secondary school, and can be regarded only as a transitional stage in the development of an organised educational system.

The subjoined summary of the conclusions arrived at by the President of the Carnegie Foundation, as the result of a detailed discussion of the problem, is particularly worthy of consideration in connection with the inquiry of the present Committee; for the views expressed are as applicable to our own schools and colleges as they are to similar institutions in the United States:—

> The President of the Foundation urges that this whole question be approached by secondary school men and college men in a spirit of co-operation. Neither the certificate method of admission nor the piecemeal examination method have in his opinion solved the problem. He urges that the college must find a solution which will test better than the certificate or the piecemeal examination the fundamental qualities of the student, and will at the same time leave to the high school a larger measure of freedom. He recommends a combination of certificate and examinations, the latter of a simple and elementary character, but calling for a high quality of performance without which the candidate will not be admitted. For example, under this plan the boy who cannot write good idiomatic English would not be admitted to college at all, but would be sent back to the secondary school. The President of the Foundation urges a co-operation between the secondary school and the college not as unrelated institutions, but as two parts of a common system of education. He argues that the interest of the great mass of high school students must not be sacrificed to the interest of the minority who are looking toward college. He insists on a larger measure of freedom for the secondary school, but on the other hand he argues that the interest of the boy who goes to college and of the boy who goes from the high school into business are alike conserved by learning a few things well, not by learning many things superficially. The boy who has obtained such intellectual discipline is a fit candidate for college, whether he has studied one set of subjects or another; without this intellectual discipline he is unfit alike for college or business. It is therefore, in the opinion of the President of the Foundation, the plain duty of the college to articulate squarely with the four-year high school and to leave to the secondary school the largest freedom so that it may educate boys, not coach them; but at the same time to require of the candidates for admission tests which rest upon high performance in the elementary studies and mean mastery of the fundamentals.

In the present inquiry the Committee decided to deal, in the first instance, only with schools, colleges, and universities in England, and not to consider the special subject of the relationship between

secondary schools and medical schools. For the purposes of the inquiry the various institutions were classified as follows:—

I. Universities.
II. Polytechnics and other Technical Schools and Colleges.
III. Secondary Schools for Girls.
IV. Public Schools represented upon the Headmasters' Conference.
V. Boys' Secondary Schools other than those represented upon the Headmasters' Conference.

The chief points upon which questions were asked related to the extent to which schools are doing work of a university character and how far universities are concerned with work of a secondary school standard. The results of the inquiry as regards each of the foregoing divisions of educational institutions in England, except No. V., will now be given.

I. UNIVERSITIES.

Inquiry was made of a large number of teachers and others representing English Universities, with the view of eliciting information as to the following points:—

General Question.

Are the universities attracting students who ought to be at school, and are the schools retaining students who ought to be at the University? Are the universities doing work that should be done in schools, and are the schools doing work that should be done at the universities?

Specific Questions.

1. In what subjects, and for how many students approximately, do you think that teaching is being conducted at your University which should properly be carried on at school?
2. To what cause, in your opinion, is this due?
3. How do you think this is to be remedied?
4. In your opinion, would matters be improved by any change in the age limits now fixed for matriculation or degree examinations?

In reply to these questions much valuable information was obtained from leading representatives of university education. An attempt is here made to summarise the views expressed. In the case of London the summary includes the substance of replies received from the Imperial College of Science and Technology.

Some correspondents do not think that there is any serious overlapping; others regard it as unavoidable and not undesirable; but the large majority consider that there is a real and serious duplication which is harmful and should, if possible, be prevented. The conditions in the universities are so different that the replies concerning them must be considered separately.

Oxford.

From Oxford comes the complaint that a certain number of undergraduates proceed to the university without having passed Responsions or an exempting examination; these, however, are only few in number. Both here and at Cambridge the average age of undergraduates when they enter, rather above than below eighteen, prevents this from being

much of a grievance. There is some complaint that boys are kept at school after they are ready for the university; many public schools being reluctant to part with boys who are useful in their houses, or good at games, until the latest possible time.

Some hold that Classical Pass Mods., which involves perhaps as many as 500 students at one time of the year, and about 250 at another —that is, about 60 per cent. of the men reading for Final Schools in Literæ Humaniores, Law, and Modern History—is really school work, and it is proposed that the remedy for this is a real Entrance examination. There might then be an Intermediate examination with various options, introductory to the Final Honour Schools, but also forming part of the course for a Pass Degree.

On the other hand, the opinion has been expressed that Pass Mods. is not a bad thing, for it teaches undergraduates to read a Latin or Greek text thoroughly, and introduces them to Logic. Considerable waste of time might be avoided by encouraging such men to begin their Final Schools' work as soon as they come up and to carry it on simultaneously with their work for Pass Mods.

Honour Classical Mods., which affects about 170 students each year, is by some regarded as a mere duplication of Sixth Form work at school; and it has been suggested that if students are not encouraged to come to the university younger the better men should be allowed to enter for Honour Mods. after six months.

A good deal of the work for the Preliminary examinations in science is stated to be really school work. The scholarship system, which sends boys up with an insufficient knowledge of the elementary parts of a good many subjects, is partly responsible for this and for some of the other duplication. Thus, some students who are reading for Final Honours are very imperfectly equipped in preliminary subjects: *e.g.*, mathematics for engineering students and German for science students.

Cambridge.

Much that has been said concerning Oxford applies *mutatis mutandis* to Cambridge. Here again it is stated that many boys are kept longer at school than is to their advantage. Several correspondents state that 300 or 400 students attending lectures for the Previous examination are doing work that should have been done at school. Little-go lectures are regularly given at some colleges. The remedy proposed is to abolish the Previous and to replace it by a real Entrance examination, or to convert it into one.

There is the same complaint, as at Oxford, concerning the effect of Entrance Scholarships and the consequent omission of elementary training which should have been supplied at school. For example, the English of many science students is very defective.

Neither from Oxford nor Cambridge is the opinion expressed that matters would be improved by any alteration in the age limits for Matriculation; and opinions are divided on the question whether boys should be encouraged to come up younger than eighteen or nineteen. But at these universities the matter is, of course, in the hands of the colleges.

London.

Here the question is far more complicated. It is confessed by most of those who have expressed an opinion that there is a great deal of overlapping between the Matriculation and Intermediate stages. The External system of this university renders it possible for the Intermediate and even the Final examination to be taken from school. It is therefore to be expected that there is more university work being done at school than school work at the university, so far as London is concerned. Moreover, the situation is different from that at Oxford and Cambridge even for Internal students, for many of them come to the university at a younger and many at a more advanced age. Further, the evening students in London form a distinct class of considerable magnitude who are working under different conditions.

A considerable amount of preparation for Matriculation takes place at the colleges in London. At one college about 100 day students are taking Matriculation classes; at another college about thirty day students and forty evening students are doing so; and there are probably some at most of the colleges. Some Intermediate students are attending Matriculation classes. Opinions are very much divided as to the desirability of allowing Intermediate work to be done both at school and at the university. Some think it a good and others think it a bad plan. Some hold that the Intermediate students are a good element at schools and correspond to post-graduate students at the university. At one of the Women's Colleges connected with the university it is stated that about 20 per cent. of the students working for the Final courses took the Intermediate before they entered, and the number is increasing.

Among the criticisms that have been received from various individuals are statements that the French, German, and mathematics for science students is largely schoolwork; that the first year's science for engineering students should have been done at school; that elementary Greek has to be taught for the Intermediate Arts to those who have not taken it at Matriculation; that work in the higher forms of Public schools for boys and girls in classics and mathematics is often up to Pass B.A. standard; that the Pass B.A. really corresponds more to work of the Ober Gymnasien and Ober Realschulen; that it would be better for clever boys who intend to be medical students not to do any science at school; and, finally, that those who have done their Intermediate science at school do not do so well as those who have done it at the university.

The problem in London is complicated by many special circumstances. Evening students are often of an advanced age, and must be provided with elementary teaching. Day students who enter colleges between the ages of fifteen and eighteen are not always really prepared for the university. Students who are training for the ministry often come to the university too old to get elsewhere the elementary training which should have been done at school. Many women cannot afford to stay more than three years at a residential college, and therefore, if they wish to devote three years to their final course, they are forced to take their Intermediate examination at school.

Some persons think that to raise the age for Matriculation would help matters; others consider that the ages for Intermediate and Finals should be raised; while a third view is strongly opposed to such changes. There are those who think that the School-leaving examination should be of the present Intermediate standard, and that the Pass B.A. should be abolished on the ground that it is really of school standard.

On the whole there is very widespread feeling that, so far as London is concerned, there is considerable overlapping both on the side of university work done at school and of school work done at the university.

Other Universities.

Opinion from the provincial universities and university colleges seems to indicate that a decided amount of overlapping exists between the university work and that of the Secondary schools. There is, however, little definite complaint on the subject, and in the case of one university, indeed, the schools are encouraged to retain their better pupils in order that they may pass the Intermediate examination of the university work and that of the secondary schools. It is believed that pupils thereby benefit from receiving the full period of school discipline, and also from being able to reach a higher standard during their three years at the university. Other universities protest strongly against allowing any work of university standard to be carried on in the schools. There is some complaint as to want of general education and of the admission to the university of pupils who should not be admitted, not merely because they are ill-prepared, but because even a longer period at school would probably not have brought them to the necessary level. Attention is directed to overlapping in the teaching of Elementary Science, but it is not altogether deplored. It is felt to be an advantage both for the students to have preliminary scientific knowledge before coming to the university and also to revise this elementary knowledge in the university, where it has to serve as the basis of a professor's particular system.

II. POLYTECHNICS AND OTHER TECHNICAL SCHOOLS AND COLLEGES.

Most of the work of the technical schools and colleges in England is carried on in evening classes and does not therefore come within the scope of the present inquiry, which is concerned in this section with the extent to which the day work of such institutions may be considered to belong to secondary schools. On account of the diversity of functions exercised by technical schools and colleges it is perhaps desirable to describe briefly the characters of the classes which are conducted in these institutions before proceeding to inquire as to overlapping with secondary schools.

A technical school or college may have under the same roof, or directly connected with it, (1) a day secondary school; (2) a technical institution; (3) day technical classes; (4) a school of art; (5) evening schools and classes. Each of these types of instruction is recognised by a regulation of the Board of Education, and grants are made for

it. The various schools and classes are defined by the Board as follows:—

1. *Secondary Schools.*

A secondary school, in the sense in which the term is used in the Board's regulations, must offer to each of its pupils a progressive course of instruction (with the requisite organisation, curriculum, teaching staff, and equipment) in the subjects necessary to a good general education, upon lines suitable for pupils of an age-range at least as wide as from twelve to sixteen or seventeen. The provision, if any, made for pupils below the age of twelve must be similarly suitable, and in proper relation to the work done in the main portion of the school.

The regulations also require that an adequate proportion of the pupils must remain at least four years in the school, and that an adequate proportion must also remain up to and beyond the age of sixteen; but these requirements may be reduced to three years and the age of fifteen respectively in the case of rural areas and small towns, where such a course appears to the Board to be advantageous in view of local circumstances.

2. *Technical Institutions.*

A technical institution, within the meaning of the regulations (Article 35) of the Board, is an institution giving an organised course of instruction in day classes, including advanced instruction in science, or in science and in art, and provided with a staff and equipment adequate for the purpose. Provision must be made in such institutions for at least a two years' systematic course in science, or in science and in art, either alone, or in conjunction with subjects of general commercial, manual, or technological instruction. Except that for the present students may be admitted between the ages of fifteen and sixteen, the attention of the Inspector being specially drawn to any such student, no student may be admitted to the course unless he has passed through at least a three years' course of instruction in a school recognised under the regulations of the Board for secondary schools, or is over sixteen years of age and is qualified from his general education to profit by a course of advanced instruction.

3. *Day Technical Classes.*

Grants are payable under Article 42 of the Board's Regulations for Technical Schools, &c., to schools and classes which are, as a rule, for students younger than those in the technical institutions. Under this category there are included, however, some classes of a standard equal to that required in a technical institution, but with courses not of sufficient duration to be eligible for grants as technical institutions. Day technical classes vary in their aims, some being preparatory to trades, such as engineering, others providing instruction of a domestic type, others again being for blind or deaf students. The classes are held in technical schools and colleges, and may be classified as (1) commercial day schools; (2) trade preparatory schools; (3) special trade schools; (4) domestic economy schools for girls; (5) training schools for domestic economy teachers; (6) detailed classes.

4. *Schools of Art.*

A school of art, as defined by the regulations of the Board, is an institution giving an organised course of instruction, including advanced instruction, in ornamental and decorative art. The work must be carried on methodically under recognised teachers, in day and evening classes, for not less than thirty-six weeks in the year, and the opportunities for instruction and practice in the several subjects must be adequate. The regulations for 1908–09 required that the day classes must meet on at least two days a week for two hours at each meeting, and that the evening classes must meet on at least three evenings a week for two hours at each meeting.

5. *Evening Schools and Classes.*

The defining feature of these schools and classes is that they are intended to maintain educational facilities for those already engaged in some occupation which takes up the greater part of their time. The usual time of meeting is therefore

in the evening, or on Saturday afternoons; but where the conditions of employment, or other circumstances, render a different time more convenient, classes meeting in the day-time may be recognised under the same category, and may receive the same grants as classes meeting in the evening. The classes vary very widely in character and scope, for they range from the small and unambitious continuation classes of a rural school to the highly specialised work done in the best equipped of the technical colleges.

This section of the Committee's inquiry need only be concerned with the question whether the work of day technical classes and of technical institutions, as defined by the regulations of the Board of Education, overlaps that of secondary schools; and if so, to what extent. Particulars of the number and ages of students in these two groups are given in the volume of the 'Educational Statistics for 1908-09' issued by the Board (Cd. 5355; price 4*s.* 2*d.*), and from the tables in that volume the following numbers have been extracted:—

TABLE I.—*Technical Institutions* (*England*).

1. Number of institutions and courses :—	1908-09.
(*a*) Number of institutions recognised	40
(*b*) Number of courses	121
2. Students :—	
(*a*) Number of students who attended a full course of instruction	1,902
(*b*) Number of students who attended at any time during the year :—	
(i) Age at date of first registration for the session :—	
15 and under 16 years of age	211
16 „ „ 18 „ „	835
18 „ „ 21 „ „	1,360
21 years of age and over	908
(ii) Sex :—	
Boys and men	3,091
Girls and women	223
(*c*) Number of students returned as having been previously educated :—	
(i) At public elementary (including higher elementary) schools only	264
(ii) At secondary schools on the Efficient List :—	
(α) For four years after reaching the age of twelve	660
(β) For three years after reaching the age of twelve	423
(iii) Otherwise	1,222
(*d*) Number of students returned as admitted :—	
(i) On account of passing a university Matriculation (or equivalent) examination	669
(ii) On account of passing an examination recognised by the institution as a test of ability to profit by the courses	1,160
(iii) Without passing any such examination test	908

In reply to an inquiry, the Board of Education has kindly informed the Committee that the forty technical institutions referred to in the foregoing table are distributed as shown below. It will be noticed that the Board recognises as work of technical institutions the courses in engineering and other branches of applied science carried on in some of the provincial universities. The two thousand students who attended full courses of instruction in technical institutions in 1908-09 thus include a number of students of technology in universities. As to the Day Technical Classes in Table III., the Board estimates that the number of students doing work which approximates to the standard of a first year's course or higher in a technical institution is about 400, the remainder being below that standard.

TABLE II.—*Technical Institutions under Article 35 of the Board of Education's Regulations for Technical Schools, &c.*

Cornwall	Mining School, Camborne; School of Mines, Redruth.
Derbyshire	Municipal Technical College, Derby.
Devonshire	Municipal Technical School, Plymouth.
Durham	Technical College, Darlington; Municipal Technical College, Sunderland.
Essex	Municipal Technical Institute, West Ham.
Gloucestershire	Royal Agricultural College, Cirencester; Merchant Venturers' Technical College, Bristol.
Hampshire	Municipal College, Portsmouth; Hartley University College, Southampton.
Kent	Horticultural College, Swanley.
Lancashire	Municipal Technical School, Blackburn; University of Liverpool (Engineering and Architecture); Municipal School of Technology, Manchester; Victoria University, Manchester (Engineering); Harris Institute, Preston; Royal Technical Institute, Salford; Wigan and District Mining and Technical College, Wigan.
Leicestershire	Municipal Technical School, Leicester.
London	Battersea Polytechnic; Herold's Institute, Bermondsey; South-Western Polytechnic Institute, Chelsea; Northampton Polytechnic Institute, Finsbury; Northern Polytechnic Institute, Holloway; St. Mary's Hospital Medical School, Paddington; The Polytechnic, Regent Street; East London College, Stepney.
Northumberland	Armstrong College, Newcastle-on-Tyne (Engineering, Naval Architecture, and Mining); Rutherford College, Newcastle-on-Tyne (Engineering).
Nottinghamshire	University College, Nottingham (Engineering and Mining).
Surrey	School of Horticulture, Wisley.
Sussex	Municipal Technical College, Brighton.
Warwickshire	University, Birmingham (Engineering, &c.).
Yorkshire (East Riding)	Municipal Technical School, Kingston-upon-Hull.
Yorkshire (West Riding)	Technical College, Bradford; Municipal Technical College, Halifax; Technical College, Huddersfield; University, Leeds (Engineering, Textile Industries, &c.); University, Sheffield (Department of Applied Science).

TABLE III.—*Day Technical Classes (England) under Article 42 of the Board of Education's Regulations for Technical Schools, &c.*

	1908–09.
1. Number of institutions and courses :—	
(*a*) Number of institutions in which day technical classes were recognised	100
(*b*) Number of courses for which grants were paid	175
2. Students :—	
(*a*) Number of students who attended at any time during the year :—	
(i) Age at date of first registration for the session :—	
12 and under 15 years of age	3,380
15 „ „ 18 „ „	2,759
18 „ „ 21 „ „	1,128
21 years of age and over	2,799
(ii) Sex :—	
Boys and men	5,700
Girls and women	4,366
(*b*) Number of students returned as having been previously educated at—	
(i) Public elementary schools	6,935
(ii) Secondary schools	2,316

To supplement the particulars provided by the Board of Education's volume of statistics, a circular of inquiry was sent to the principal, director, or headmaster of the seventy-one polytechnics, technical schools, and colleges in Great Britain and Ireland represented upon the

Association of Technical Institutions. For a list of these institutions and a suggested form of inquiry the Committee is indebted to Dr. R. S. Clay, until lately secretary of the Association. University College, Nottingham, Hartley University College, Southampton, and the Technical Department of Sheffield University are also represented in the Association, but as they are included in another section of this report the circular was not sent to them. The circular asked for information on the following points:—

QUESTIONS ASKED OF POLYTECHNICS AND OTHER TECHNICAL COLLEGES AND SCHOOLS.

1. Is there a secondary day school at your institution ....

If so, (*a*) total number of students in this school ....

(*b*) Number of students above the standard of London Matriculation or similar general examination ....

***Note.*—Day trade-schools, preparatory trade-schools, apprenticeship schools, and domestic economy schools are to be excluded from the particulars desired in Question 2 below.**

2. Total number of day students in university courses, or in engineering, building, textile, or other technical courses ....

(*a*) Number of such students doing first year's work ....

(*b*) „ „ „ second „ ....

(*c*) „ „ „ third „ ....

(*d*) Number of such students, if any, in Preliminary or Preparatory classes continuing the subjects of an ordinary general education not higher than the standard of London Matriculation ....

3. Remarks as to Preparatory classes ....

Replies were received from fifty-nine technical colleges and schools in England. Of this number, twenty have secondary day schools connected with the technical schools, though usually independent as regards staff and organisation. The total number of students in these secondary schools is about 5,000, of whom about 200, or 4 per cent., are above the standard of London Matriculation or its equivalent.

At the secondary school attached to the Technical Institute, Swindon, the percentage is much higher, no fewer than twenty-seven pupils out of a total of 220 having attained the standard of London Matriculation. This, however, is unusual, and the Principal of the school remarks:—

> **Although I have so many post-matriculation students in the secondary school, I am strongly of the opinion that it would be better if all except those who are preparing for University Scholarships were now regular students of those higher institutions which they will ultimately join.**

It cannot be said that the schools connected with technical colleges are to any appreciable extent doing work of institutions of a higher grade. The work of the schools is usually planned to enable the Sixth Form to take the London Matriculation examination; and to the few students who have matriculated opportunities are given to remain another year preparing for the examinations of Intermediate science or

arts. In some of the schools special courses in engineering and other technical subjects are provided for pupils in the upper forms. At the Cockburn Technical School, Leeds, for instance, with a total of 450 boys and girls as pupils, from twenty to thirty (ages fourteen to sixteen) take a special course in engineering subjects as part of their school course. At the Technical Institute, Keighley, with a total of 280 pupils, boys who have reached the age of fifteen years and are fitted by their educational progress are permitted by the Board of Education to take seven hours a week in the textile department instead of continuing their work in general physics and chemistry.

TABLE IV.—*Day Students in Polytechnics, Technical Schools, and Colleges (England).*

——	Students in Preparatory Courses	Number of Students			
		First Year	Second Year	Third and Fourth Years	Total
Blackburn, Municipal Technical School	—	11	6	3	20
Bolton, Municipal Technical School	—	11	13	—	24
Bradford, Technical College	0	92	68	54	214
Brighton, Municipal Technical College	0	39	14	11	64
Camborne, Mining School	1	29	41	25	95
Coventry, Municipal Technical Institute	0	44	24	15	83
Derby, Municipal Technical College	—	24	35	18	77
Huddersfield, Technical College	12	42	35	31	108
Leicester, Municipal Technical School	10	44	26	—	70
London, Battersea Polytechnic	15	180	92	77	364*
London, Birkbeck College	60	57	12	20	89
London, Northampton Polytechnic Institute	0	42	15	30	87
London, Northern Polytechnic	13	24	17	12	53
London, Regent Street Polytechnic	0	60	32	18	110
London, South-Western Polytechnic	3	49	28	20	97
Manchester, Municipal School of Technology	0	149	119	78	346
Plymouth, Municipal Technical Institute	—	22	10	7	39
Portsmouth, Municipal College	—	26	47	31	104
Preston, Harris Institute	37	54	34	20	108
Rochdale, Municipal Technical School	—	19	—	—	19
Salford, Royal Technical Institute	—	45	12	8	65
Swindon, Technical Institute	—	56	16	15	87
West Ham, Municipal Technical Institute	13	24	10	11	45
Wigan, Mining and Technical College	—	3	4	2	9
Total	164	1,146	710	506	2,377

* Including the Domestic Science Training Department, in which all students are eighteen years of age, or above.

The results of the inquiry as regards technical schools and colleges in England are shown in Table IV. For the particulars supplied by the principals of the institutions included in the table the Committee desires to express their thanks. When no definite information was given as to number of students, a line is placed in the appropriate column instead of a number. It may be noticed that Table IV. does not include some of the colleges and technical departments of universities named in Table II. as technical institutions recognised by the Board of Education. From a list issued by the Board it has been possible, however, to find the number of day students taking technical courses in such institutions as are not included in Table IV.; and the results are shown in Table V. The total number of day technical students included in Tables IV. and V. will be seen to be about 3,900.

TABLE V.—*Technical Students in Schools and Universities (England) not included in Table IV., but recognised by the Board of Education as Technical Institutions.*

	Number of Students
Birmingham, University	180 *
Bristol, Merchant Venturers' Technical College	73
Cirencester, Royal Agricultural College	73
Darlington, Technical College	22
Halifax, Municipal Technical College	28
Kingston-upon-Hull, Municipal Technical School	30
Liverpool, University	115
Leeds, University	183 *
London, Bermondsey, Herold's Institute	11
,, East London Technical College	106 *
Manchester, University	91
Newcastle-on-Tyne, Armstrong College	107
,, Rutherford College	17
Nottingham, University College	48
Redruth, School of Mines	13
Sheffield, University, Department of Applied Science	130
Southampton, Hartley University College	24
Sunderland, Municipal Technical College	57
Swanley, Horticultural College	66
Wisley, School of Horticulture	35
Total	1,409

* Including in the case of the University of Birmingham forty-one students taking subjects preliminary to courses in engineering; in Leeds University thirty-three such students; and in the East London Technical College twenty-three such students.

It will be seen from Table IV. that the Municipal School of Technology, Manchester, occupies a leading position among technical institutions. There are nearly 350 day students, none of whom are under sixteen years of age, taking organised courses; and in addition, nearly 500 students attend special courses during the day. The opinion of the Principal, Mr. J. H. Reynolds, upon the relation between secondary and technical institutions is, therefore, of value. Mr. Reynolds writes in reply to the Committee's circular:—

> On the general question I do not think that technical schools should undertake work which is peculiarly the province of secondary schools. I am at the same time aware that there are difficulties in carrying out a policy of this kind in

certain areas, and would like my opinion to be recorded bearing in mind circumstances of this kind.

I am convinced that the secondary school should restrict itself to subjects of general education, in preparation for specialised courses in technical schools or in universities, and that it is to the advantage of education that the two classes of institutions be kept entirely separate in their sphere of work.

Summary relating to Polytechnics, &c.

The work of day technical classes cannot be said in any way to overlap that of secondary schools. In the main it consists of preliminary training for apprentices or other specialised preparation for industrial, commercial, agricultural, or domestic life, and is equally suitable for students who have received their previous education either at public elementary or at secondary schools. The courses followed could not form part of the work of a secondary school, and few of the students would attend secondary schools even if day technical classes did not exist.

The day classes at the Borough Polytechnic Institute, London, S.E., belong entirely to day schools of the preliminary trades type. There are no students above the standard of London Matriculation or similar general examination; and the 464 day students in the Institute are grouped as follows:—

	Pupils
National School of Bakery and Confectionery . . .	36
Technical Day School for Boys	200
Trade School for Girls	168
Domestic Economy School for Girls	60
	464

Schools of this type stand by themselves and do not interfere with secondary schools on the one hand or higher technical training on the other.

As to technical institutions, a certain amount of the day work, namely, that of the preparatory classes, may perhaps be considered as belonging to secondary education rather than technical. A number of students enter the day classes of technical institutions at too late an age to be admitted to secondary schools, and it is largely on their account that the preparatory classes are necessary. It appears from the numbers given in Table I. that less than one-fifth of the students in the technical institutions of England had passed a university Matriculation examination or its equivalent upon entrance, and that nearly one-quarter was admitted without passing any examination test. 'There is still a tendency,' says the latest report of the Board of Education, 'to admit students to technical institutions before they have had an adequate course of general education.' As, however, the number of students under sixteen years of age at entrance is only about 200, the overlapping so far as age is concerned is not very great; and technical institutions cannot be said to compete with secondary schools to any serious extent. From the latest report of the Board of Education it appears that in the year 1908-09 there were fewer than 2,000 students taking full courses of instruction in technical insti-

tutions in England and Wales connected with the Board of Education, this number including students of technology in several provincial universities or university colleges. Of these students, 806 were engaged in the work of the first year, 653 in that of the second, 403 in that of the third, and 125 in still more advanced work. If the standard of entrance to a technical institution, as defined by the Board, were that of a secondary school Leaving Certificate or university Matriculation, most of the institutions would be unable to exist. The Board of Education's statistics reveal, in fact, the poverty of the position of systematic technical education in England as regards day classes. Referring to this point, the Board remarks, 'The total amount of advanced instruction of the kind provided in technical institutions is still disappointingly small. In some of the more important industries, as, for example, engineering, the instruction is largely utilised by students; but in a great many others the supply of students is very small. It is to be deplored that there are several schools in which the well-qualified staffs and the excellent equipment practically stand idle in the day-time through lack of students.'

III. SECONDARY SCHOOLS FOR GIRLS.

In the case of these schools it was considered desirable to send personal letters, asking for information as to overlapping between the school education and that of universities, &c., to representative secondary schools for girls instead of issuing circulars to all girls' secondary schools.

In order to determine which schools should be chosen, reference was made to the volume published recently by the Committee appointed by the Headmistresses' Association to report on the curricula of public secondary schools for girls.

A list is given in that volume of girls' secondary schools 'considered in some ways to be typical of many others and to include every variety of public secondary schools for girls.'

Letters enclosing a list of the questions to which answers were requested were sent, therefore, to these schools and to a few others in addition, and in most cases the required information was obtained. Inquiries were made to elicit information on the following points:—

1. Number of girls in the school.
2. Number of girls who at the end of the school year 1909–10 were qualified for entrance into a university.
3. How many of these girls are still at the school?
4. What the above girls are doing.
5. Opinion *re* 'overlapping.'

The total number of girls in attendance at the schools from which information was received was 8,734. In 1910, 410 girls—nearly 5 per cent. of the present number—had passed some examination qualifying for entrance into a university; and of these girls, 225—that is, about 56 per cent.—have remained at school after passing the examination. Most of those girls who are now at school and are

already qualified for entrance into a university are doing work which may be included under one of the following heads:—

1. Preparation for Intermediate Arts or Intermediate Science.
2. Preparation for the Final B.A. (five from one school alone).
3. Preparation for a scholarship examination at a university.
4. Preparation for the Cambridge Higher Local.
5. Preparation for entrance into certain training colleges.

A great difference exists between the views on the subject of 'overlapping' expressed by (*a*) Headmistresses of schools outside London and (*b*) Headmistresses of London schools:—

(*a*) Most of these, including headmistresses of large schools in Birmingham, Leeds, Manchester, and Wakefield, consider there is no difficulty as regards overlapping. One headmistress says: 'The fact that there is no overlapping here shows, I think, the value of the local university and the importance of having a close relation between the school and it.'

(*b*) With one exception all the London headmistresses who express opinions on the subject of overlapping agree in stating that they are in favour of girls staying at school after they have matriculated, and taking higher work. One headmistress states that she would like all girls who had matriculated to stay on for a year, as she considers: (1) They are often too young and immature to go straight to college; (2) It is important for the staff to do more advanced work; (3) It is good for the school as a whole to have work beyond Matriculation, as the standard of the final school is thereby raised.

The opinions expressed by two headmistresses of long experience are here given in full:—

North London Collegiate School (Mrs. Bryant).

'In schools like this, Matriculation is taken (generally in the form of the Senior School examination of the University of London) in the Upper Fifth Form. The Sixth Form studies are on the lines (1) of Intermediate Arts or (2) Intermediate Science, except in the case of those who are specialising more closely in preparation for Oxford and Cambridge. Since the leaving age is nineteen, girls frequently take two years in the Sixth Form, when the method of work is transitional between school and university. These girls generally take Honours courses at the university, and, by having passed Intermediate Arts or Science at school, they have three years for their Final Honours work in London, as they would have if they became students at Cambridge. Others who enter the university with Matriculation attainments only become, with some exceptions, Pass students.

Thus the Sixth Form overlaps the university with respect to the course for Intermediate examinations in the colleges. By doing so it increases the supply to the university of the better type of student more developed in intelligence, more mature in character, with more independent habits of study. On the other hand, the colleges, by overlapping with the schools, make it possible for boys and girls with fewer advantages to enter the university at an earlier age, and go out into the world on a shorter, but still sufficient, course of higher education. There are only two alternatives to overlapping: (1) To level down by the abolition of Sixth Form work, and (2) to level up by raising the standard of university entrance. Each of these alternatives would, in my opinion, have disastrous effects. A certain amount of overlapping appears to me to be highly beneficial.'

Clapham High School (Mrs. Woodhouse).

With regard to 'overlapping,' I feel strongly the desirability of encouraging girls to remain longer at school, and not to enter the university before the age of

> nineteen at the earliest. I consider that at the age of seventeen or eighteen girls profit more by school than by college instruction—by reading under the guidance of a teacher rather than a lecturer. I believe that a distribution of labour on these lines between school and university would in the long run much improve the average quality of university students.
>
> But the scholastic view weighs less with me than does the advantage which girls gain in character by facing the responsibilities and the privileges given by the characteristic spirit of a Sixth Form, and which are as valuable in the formation of the character of girls as is the case with public school Sixth Form boys. I may add that I have reason for believing that the above statement represents the general opinion of the Association of Headmistresses as a whole.

The regulations of some London training colleges are held to be responsible for a certain amount of overlapping between secondary and university education. On this point, Miss Clement, the Headmistress of the Godolphin and Latymer Girls' School, Hammersmith, says:—

> There seems to be a great deal too much pressure and strain in the higher classes of many secondary schools, owing to the preparation of pupils for the London Intermediate Arts and Science examinations. But under present conditions this seems inevitable. The point is that many candidates from London secondary schools for open scholarships to the women's colleges must, if unsuccessful, fall back upon free places in the London Day Training College; and, as the London Day Training College openly declares its intention of entering only students who have passed the London Intermediate Arts or Science examination, the schools' first duty with regard to these pupils who compete for open scholarships is to safeguard their future by equipping them with the necessary qualifications, should they be obliged to be satisfied with gaining an ordinary Pass degree at a non-residential college. Otherwise, university work is, of course, best done at the university.

The inability of girls living at a distance from a university to meet the necessary expenses is another reason why girls are kept in school. The headmistress of one school, not in London, but in which there are at the present time five girls preparing for the Intermediate Arts and five for the Final B.A., states that 'all the girls who are doing degree work are quite unable owing to poverty to enter into residence at any college.'

Consideration of the information received from various sources shows that the question of overlapping between girls' secondary education and university education is especially prominent in connection with the University of London. Several headmistresses think that the Intermediate Arts and Intermediate Science work is better taken at school than at the university; and one remarks: 'Intermediate work is properly VIA Form work and does not really trench on university work.'

IV. PUBLIC SCHOOLS REPRESENTED BY THE HEADMASTERS' CONFERENCE.

It is always difficult to define a 'Public School,' but in this section of the report it has been assumed that the chief difference between such schools and the grammar schools is that the former keep their pupils to a later age than do the latter; it may be that as an indirect result of this they draw their pupils from a more wealthy and possibly higher social class of parent, but this is chiefly due to the fact that a poor man cannot afford to keep his boy at school sufficiently long for him

to be able to reap the full benefit of the Public School system; that it is not solely a question of the fees charged is proved by the fact that of the 101 schools represented upon the Headmasters' Conference no fewer than thirty are in receipt of Government grants.

Circulars were sent to about thirty-five schools represented upon the Headmasters' Conference, the selection being made to include about equal numbers of the larger and smaller schools. Questions were asked as to the number of boys at present in the school who had passed the various university examinations, and what they were then reading; also whether in the general opinion of the masters in the school it was advisable for boys who had passed a university examination to spend the remainder of their school life in reading the subject they would study at the university if that subject was (*a*) classics, (*b*) mathematics, (*c*) science, (*d*) history.

Since the especial aim of the Public Schools is to develop the sense of responsibility and the power of command in their boys, and these can only be acquired by the older pupils, there is a unanimous feeling on the part of the masters in such schools that nothing should be done to discourage the boys from remaining at school until they are eighteen or nineteen years of age; if, however, they are to do this it follows that unless boys entering the Public Schools are less able than those who join the grammar schools (and of this there is no evidence), the various subjects taught can, and must, be carried to a more advanced stage in the former than in the latter. In other words, there must be a certain amount of overlapping between the subjects taught in the Public Schools and in those universities which draw their undergraduates chiefly from schools in which the average leaving age is sixteen.

The tutorial system at Oxford and Cambridge prevents any of the undergraduates from being obliged to attend lectures unsuited to their requirements; those who begin the study of a new subject, *e.g.*, science, are able to attend the lectures given to pass-men; while those who go up with a certain amount of groundwork already covered are advised by their tutors which lectures can be omitted with advantage. On the other hand, there seems to be no adequate tutorial system in force at most of the colleges of the London University, and frequent complaints are received at the Public Schools from the old boys that they are obliged to waste the greater part of their first year in going over work they have thoroughly mastered at school: this chiefly affects those boys who have spent a year at school after passing the Matriculation examination but have not succeeded in reaching the standard of the Intermediate B.A. or B.Sc.; it certainly seems to be desirable that there should not be so sharp a distinction drawn by the London colleges between their first and second year courses, and that those who are able to do so with advantage should be allowed to attend second-year lectures, even if they have not passed the Intermediate examination.

All the schools to which circulars were sent, with the single exception of the City of London School, reply that in their opinion boys who have passed some examination in general education should be allowed to spend the greater part of their remaining school life in working at

the subject which will form their special study at the university. It is, however, widely felt that a smaller amount of time should be devoted to some other work which will tend to widen their minds, *e.g.*, those who are to take a degree in classics should also read a certain amount of modern history, those who aim at a science degree should learn German, and for those who are to read mathematics or history a course of elementary science should be provided.

The following opinions are typical of many letters received:—

MR. O. H. LATTER (Charterhouse).

I have no hesitation whatever in pronouncing in favour of boys staying on at school after passing the Entrance examination to a university. If a boy has the natural aptitude for classics, and if his father's purse is deep enough, by all means let him enlarge his mental outlook as much as possible. But the majority are boys whose intellectual bent is in the direction in which they incline to specialise; and in such cases I do not see why the side of the mind which can be cultivated *con amore* should not get its opportunity at school.

I am dead against the idea that a boy should leave school at sixteen. It is those last years from sixteen to eighteen that give our English Public Schools (and Englishmen) the quality that is the envy of the world. It is then that they learn self-control, how to use authority, and all the most valuable part of character-training. I am not blind to the faults of our Public Schools, but I would sooner continue many of these than sacrifice the one thing which has gone a long way towards forming our conception of an English gentleman. Reform us in some matters if you like, but do not interfere with that remarkable mixture of self-government and tutelage that is our peculiar possession, and that no other nation in the world attempts.

MR. C. F. MOTT (Giggleswick)

During his last few terms at school a boy who aims at an Honours degree at the university should run no risk of losing ground in his special subject. He should therefore devote a considerable time to it. English should be retained for the sake of general culture, and subjects which are likely to be useful should be added; *e.g.*, a science student should give attention to mathematics and modern languages. It is greatly to the advantage of a boy who is going to specialise at the university to remain as long as possible at school, if the conditions are such that a master or masters can give him a good deal of attention and help in his special work, which is generally the case at Public Schools.

There can be little or no overlapping between Public Schools and Oxford or Cambridge, as it is not customary to enter these universities before the age of nineteen nor, in most cases, possible to remain at school after that age. The Provincial universities, however, admit students at a lower age, and overlapping occurs between them and the larger secondary schools.

With regard to a break in the method of instruction, I see no reason why such a break in method, if it occurs at all, should coincide with the change from school to university. It would seem better gradually to modify the method as the age of the pupil increases, suiting it to his powers and attainments, and in the later stages accustoming him as far as possible to the methods he will find in use at the universities. Otherwise he may lose time in adjusting himelf to new conditions.

It has proved to be impossible to obtain any useful figures showing the number of boys who remain at school for any considerable time after passing some public examination, the difficulty being that in the majority of cases boys who are working for scholarships are not sent in for Responsions, &c., until they have obtained their scholarships: consequently any such figures would omit the most promising boys from the various schools, and would give a totally erroneous view of the work carried on in them.

From the returns received, however, it seems that about 8 per cent. of the boys remain at the Public Schools for at least a year after passing some university examination: those generally taken being Responsions or Previous (including the Higher Certificate of the Joint Board, which gives exemption from these), London Matriculation, and the 'School Certificate.' Of the 8 per cent. mentioned above, 31 per cent. had passed Responsions, &c., 23 per cent. London Matriculation, and 45 per cent. some 'School Certificate' founded about seven years ago to meet the requirements of the War Office for Army candidates. A considerable number of boys holding this certificate are at present on the Army sides of the various schools. The use of this examination has been extended during the past few years, however, to other parts of the school as a test for the ordinary boys who, whilst in one of the upper forms, have not reached the sixth. The hope is expressed by many schoolmasters that the recent action of the War Office in abolishing the need for a Qualifying examination for Army candidates will not cause this tendency to be arrested.

It seems to be a general opinion among the masters in Public Schools that there should be no sudden transition from the methods of teaching adopted in the schools and at the University, since in this case valuable time would be lost before the pupils became accustomed to the new methods; in fact, one correspondent suggests that there is already too little overlapping between the methods employed, and that at present there is too much lecturing and too little teaching at the universities, while in the schools there is too much 'spoon-feeding' and too little lecturing.

Changes in Regulations affecting Secondary Education.—Report of the Committee, consisting of Sir PHILIP MAGNUS (*Chairman*), Professor H. E. ARMSTRONG (*Secretary*), Mr. S. H. BUTCHER, Sir HENRY CRAIK, Principal GRIFFITHS, Sir HORACE PLUNKETT, *and* Professor M. E. SADLER, *appointed to take notice of, and report upon Changes in, Regulations—whether Legislative, Administrative, or made by Local Authorities—affecting Secondary Education.*

No changes have been made during the past year in the Regulations of the Board of Education affecting Secondary schools. Further correspondence has taken place between the Board and the Secondary Schools Association on the effect of the Regulations as regards the annual admission of 25 per cent. of the new pupils from Public Elementary into Secondary schools receiving the higher grant, and also on the advisability or otherwise of communicating in all cases the reports *in extenso* of the Board's inspectors to the Local Education Authority, even when no contribution is made from the authority to the upkeep of the school. This correspondence will be published in the Report of the Association.

An interesting statement was made in the House of Commons on July 13 by the President of the Board in moving the Vote for

Supply, in which he gave full statistics showing the increase during the past year in the number of children now receiving Secondary education, and suggested the advisability of transferring, wherever possible, children at the age of nine from the Elementary to the Secondary school. This suggestion is one which might be considered by the Committee in its effect on both grades of education.

After a long delay, there is now some prospect of a Teachers Registration Council being instituted, consisting of representatives of the teaching profession, with power to form and maintain a Register of qualified teachers. The Secretary of the Board of Education reported on July 12 of this year to the President on the result of recent negotiations, and offered suggestions for the formation of a Registration Council, and the President has appended a Minute to the Report, in which he states that he agrees with the various suggestions set out in the Report and requests the Secretary to take steps to prepare a draft of an Order in Council on the lines outlined in the Report. The proposed Council is to consist of forty-four members and a Chairman (forty-five in all) representing in equal numbers (*a*) Elementary School teachers, (*b*) Secondary School teachers, (*c*) University teachers, and (*d*) Technological and Specialist teachers.

The Council when constituted, in addition to its Registration functions, might be able to offer suggestions for the better organisation of Secondary education, which is still in an inchoate condition.

It is desirable that the Committee should be reappointed to take note of, and report upon changes which may be made during the coming year by the State, or by Local and other authorities, affecting Secondary education.

The Principle of Relativity. *By* E. Cunningham.

[Ordered by the General Committee to be printed in *extenso.*]

Bibliographical Note.

The memoirs bearing most directly on the lines of thought developed in this paper are as follows:—

(1) Einstein: 'Zur Elektrodynamik der bewegten Körpern,' *Ann. d. Phys.*, 17 1905.

(2) Minkowski: 'Die Grundgleichungen für die elektromagnetische Vorgänge in bewegten Körpern,' *Gött. Nachr.*, 1908, and *Math. Ann.*, 68, 1910; 'Raum und Zeit.,' *Phyz. Zeitschr.*, 10. 1909.

(3) Planck: 'Zur Elektrodynamik bewegter Systeme,' *Ann. d. Phys.*, 26, 1908.

(4) Einstein: 'Uber das Relativitätsprinzip und die aus demselben gezogenen Folgerungen,' *Jahrb. d. Rad. u. Elektr.*, 4, 1907.

(5) Born: 'Die Ableitung der Grundgleichungen für die elektrom. Vorgänge in bewegten Körpern,' *Math. Ann.*, 68, 1910.

(6) Cunningham: 'The Principle of Relativity,' *Proc. Lond. Math. Soc.*, 8, 1910; 'The Application of the Principle of Relativity in Electron Theory,' *Proc. Lond. Math. Soc.*, 9, 1911.

The experimental side of the subject is very fully discussed by Laub—'Uber die experimentellen Grundlagen des Relativitätsprinzip' in the *Jahrb. d. Rad. u. Elektr.*, 7, 1910, where a complete bibliography of the whole subject is given.

1.

The principle of relativity carried to its furthest extent would declare that the phenomena of physical science do not lead us to any knowledge of a permanent and unique frame of reference relative to which the motions of bodies may be determined. The principle is intimately bound up with the theory of the electromagnetic constitution of matter, but there was, in a sense, a principle of relativity before the days of Lorentz, of Maxwell, or even of Faraday. Newton, when he enunciated his laws of motion, postulated an absolute frame of reference for the position of a point. *A priori* there seems to be small ground for such a postulate, but the hypotheses of natural science have all to be justified *a posteriori*, and it does appear true that it is possible to choose such a frame of reference for the motion of material systems, that Newton's laws accurately describe the changes in the motion from time to time. But inasmuch as those laws involve not the velocities but the accelerations of the various elements of the system, it appears that the frame of reference so defined is not unique, but that any one of an infinite number of such frames, each of which has relative to any other a uniform velocity of translation, will equally satisfy the requirements; and among this infinite number there is no particular one which has an advantage over the rest in giving any additional simplicity to the general laws of motion. The frame of reference may be, however, fixed once for all by assigning to any one point at any one instant an arbitrary velocity; but the arbitrariness thus allowed to the velocity of any one point of the system does not apply to the angular velocity of any part of the system. In the light of Newtonian dynamics this vector has a unique value at each instant.

As far as the time-space co-ordinates are conditioned in this way by laws of dynamics, $(x\,y\,z\,t)$ and $(x'\,y'\,z'\,t')$ are equally valid if

$$x' = x - at, \quad y' = y - bt, \quad z' = z - ct, \quad t' = t,$$

where (a, b, c) is any constant velocity.

Transformations of this type form a group, *i.e.*, the successive application of two such transformations gives the same result as that given by a certain other transformation of the same type. If we say that two events are simultaneous if they have the same t, it is characteristic of what we may call the Newtonian group that simultaneity persists.

2.

The advent of the theory of an electromagnetic medium filling all space seemed to promise in the *æther* a unique frame of reference relative to which the velocities of points might be specified, and experiments were quickly made to determine the velocity of the earth relative to the æther, with results, as everyone well knows, which failed as completely to give evidence of any such velocity, as dynamical science had failed to give evidence of an absolute velocity of a material body in space.

In the famous Michelson and Morley experiment[1] the only suggestion that could be made to account for the failure to discover a difference between the velocities of propagation of light in different directions was that, owing to the influence of the motion through the æther, the dimensions of the apparatus were reduced in the direction of motion in the ratio $\sqrt{1 - v^2/c^2}$.

The possibility of such an automatic contraction was, of course, suggested by the gradually strengthening belief that the forces which hold the elementary constituents of a material body together are of an electrical nature—that is, are exerted through the medium of the æther filling the spaces between those elements. The search for a systematic theory, whereby a contraction of exactly this amount might be expected, independently of the nature of the body in question, of the size of its molecules, and of the distance between them, was the means of bringing into prominence a remarkable property of the equations of the electromagnetic field, which is, in fact, the whole foundation of the principle of relativity from a mathematical point of view.

This property, first noted in another connection by Voigt, was developed and applied by Larmor[2] and Lorentz.[3]

It is assumed that there is a frame of reference for which the fundamental equations in free space have the form

$$\frac{1}{c}\frac{\partial e}{\partial t} = \operatorname{curl} h \qquad -\frac{1}{c}\frac{\partial h}{\partial t} = \operatorname{curl} e$$

$$\operatorname{div} e = 0 \qquad \operatorname{div} h = 0 \quad . \quad . \quad . \quad (a)$$

where e, h are the electric and magnetic intensities, and c is the velocity of light.

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[1] v. *Phil. Mag.*, (6) 8, p. 753.

[2] v. *Æther and Matter*, p. 173.

[3] v. *Amst. Proceedings*, 1904.

Now, if a change of variables be made according to the following scheme,

$$X = \beta(x - vt), \quad Y = y, \quad Z = z, \quad T = \beta\left(t - \frac{vx}{c^2}\right), \quad . \quad . \quad \text{(i)}$$

$$\left.\begin{array}{ll} e = e + [vh]/c, & h' = h - [ve]/c, \\ E_x = e'_x = e_x \quad E_y = \beta e'_y. \quad E_z = \beta e_z' & H_x = h_x', \ H_y' = \beta h_y', \ H_z' = \beta h_z' \end{array}\right\} \quad \text{(ii)}$$

we find that the equations (a) are exactly equivalent to equations

$$\begin{array}{ll} \frac{1}{c}\frac{\partial E}{\partial T} = \text{curl } H, & -\frac{1}{c}\frac{\partial H}{\partial T} = \text{curl } E, \\ \text{div } E = 0, & \text{div } H = 0. \end{array} \quad . \quad . \quad \text{(A)}$$

The immediate consequence of this theorem is that if any solution of equations (a) be found, say

$$e = \epsilon\,(x, y, z, t),$$
$$h = \eta\,(x, y, z, t),$$

we may thence deduce a solution of equations (A), viz.,

$$E_x = e_x = \epsilon_x\left[\beta(X + vT), y, z, \beta\left(T + \frac{vX}{c^2}\right)\right]$$

$$E_y = \beta\left(e_y - \frac{v}{c}h_z\right) = \beta\left[\epsilon_y\left\{\beta(X + vT), y, z, \beta\left(T + \frac{vX}{c^2}\right)\right\}\right.$$
$$\left. - \frac{v}{c}\eta_z\left\{\beta\,(X + vT), y, z, \beta\left(T + \frac{vX}{c^2}\right)\right\}\right].$$

Suppose now that there exists a being capable of following the propagation of electromagnetic disturbances in the æther without himself affecting those disturbances, and not capable of perceiving any other phenomena whatever. Further suppose that all this being requires of his measures of space and time, of electric and magnetic vectors, is that by use of them the laws of his æthereal universe are expressed in the form (a). Then, as a consequence of the invariance of these equations, this æthereal being has no means of discrimination between ($x\ y\ z\ t\ e\ h$) and (X Y Z T E H). As far as he knows, he might sometimes be measuring in one set of variables and at other times in the other set.

If he adopted ($x\ y\ z\ t$) as space time co-ordinates then *velocity* would be defined as

$$Lt_{\delta t \to 0}\,\frac{\delta x}{\delta t}.$$

If, on the other hand, he adopted (X Y Z T), then *velocity* would be defined as

$$Lt_{\delta T \to 0}\,\frac{\delta X}{\delta T} \quad . \quad . \quad . \quad .$$

These lead at once to the transformation of velocities

$$W_X = \frac{w_x - v}{1 - \frac{vw_x}{c^2}}, \quad W_Y = \frac{w_y}{\beta\left(1 - \frac{vw_y}{c^2}\right)}, \quad W_Z = \frac{w_z}{\beta\left(1 - \frac{vw_z}{c^2}\right)}.$$

In particular, if $w_x = 0$, $W_X = -v$; and if $W_X = 0$, $w_x = v$.

If a is the acceleration of a point at rest in the ($x\ y\ z\ t$) co-ordinates,

and a' the acceleration of the same point when referred to $x'\ y'\ z'\ t'$, we have

$$a'_x = a_x/\beta^3 \qquad a_y' = a_y/\beta^2, \qquad a_z' = a_z/\beta^2.$$

3.

To discuss, however, only the equations of free space will lead us to no tangible result. It is with *material* phenomena that we are concerned. The propagation of light is only observed by means of phenomena occurring when light meets matter. The theory of matter which at present holds the field is the electron theory. We pass therefore at once to the extension of the above theorem to the equations of that theory in the most commonly adopted form—viz., that of Lorentz.

$$\frac{1}{c}\left(\frac{\partial e}{\partial t} + \rho w\right) = \text{curl}\ b\ ; \qquad -\frac{1}{c}\frac{\partial b}{\partial t} = \text{curl}\ e\ ; \qquad (b)$$

$$\text{div}\ e = \rho\ ; \qquad \text{div}\ b = 0\ ;$$

where ρ is the *density* of electricity and w the velocity with which it is moving relative to the frame of reference with respect to which these equations are assumed to hold.

We have already seen the transformation applicable to *velocity*. The only remaining quantity is ρ, and we find that if we add to (i) and (ii) the further equation

$$\text{R} = \beta\rho\left(1 - \frac{vw_x}{c^2}\right), \qquad . \quad . \quad . \quad \text{(iii)}$$

then the equations (b) above transform into identical equations connecting X Y Z T E H P W.

The relation between corresponding elements of volume δS and δs is

$$\delta\text{S} = \delta s/\beta\,(1 - vw_x),$$

so that

$$\text{R}\,\delta\text{S} = \rho\,\delta s,$$

i.e., corresponding elements of change are equal.

4.

But we cannot at once proceed to argue as above that all effects of a uniform translation will be obscured, for the reason that equations (b) are not complete, as the scheme for the free æther is. It is not sufficient to add, after Lorentz, the statement that the moving *force* is e', because that requires some assumed relation between *force* and *acceleration*—*i.e.*, some assumption about *mass* or intrinsic inertia of electricity. This extra equation of Lorentz belongs really to the stage of the derivation of the mechanical equations from the electromagnetic theory. That theory is in the above form incomplete.

A possible way out of this difficulty is to adopt the modification of the theory employed by Larmor, in which electricity is conceived as consisting of so-called isolated point singularities in the æther, *i.e.*, points at which E and B become infinite in a certain manner, and in which the original equations are assumed to be the whole scheme—holding at all points excepting those singular points—and to be sufficient to determine the motion of those points. The mathematical discussion of this aspect is, however, incomplete.

All we can say therefore is: if we had a *complete* scheme of equations for a theory embracing moving electrons, and if this completed scheme were invariant under the above transformations, then in the domain of phenomena included in this scheme it would be impossible to say that $(x\ y\ z\ t)$ rather than $(x'\ y'\ z'\ t')$ were true space-time co-ordinates.

Supposing the indicated gaps in the chain of argument to be filled, it follows that the co-ordinates which we should use in any given case depend upon what velocity we choose to assign to any given moving point at any instant, just as they do in Newtonian dynamics. Thus, the length of a given material body as far as our description of optical phenomena are concerned will depend upon what velocity we assign to the body. This is the theory of the FitzGerald-Lorentz contraction hypothesis. The measure of the time between two events at the same point will likewise be dependent upon the velocity which is assigned to the point. Thus, apart from the ordinary first order Doppler effect owing to the motion of a source of light in the line of sight, there is a second order change, which should be apparent even for bodies moving entirely at right angles to the line of sight. Laub has suggested that this transverse effect might be apparent in the Kanalstrahlen, but the experiment has not yet been carried out.

5.

Let us now turn to another aspect of the principle. Let us assume that experimental evidence is sufficiently strong to warrant our using it as a general working hypothesis—that is, we make it a test of the validity of any theory that no phenomena shall enable us to determine uniquely the velocity of a point relative to the so-called æther. We have already seen that the Lorentz fundamental equations satisfy this requirement.

The question arises as to the electrodynamic equations of ponderable matter in motion. The late Hermann Minkowski, in an already classical paper[4] which has done perhaps more than any other work to make clear the position above outlined, sought to find equations satisfying the same criterion and reducing for matter at rest to the commonly agreed upon equations of the Maxwell-Hertz theory. He obtained differential equations which differ only in notation from those of Lorentz. Translated into the notation of Lorentz the polarisation and magnetisation of bodies must be subject to the following transformations, not quite similar in form to those for E and B,

$$\begin{aligned} &\mathrm{P}_X = p_x, \quad \mathrm{P}_Y = \beta(p_y + vm_z/c), \quad \mathrm{P}\ \ = \beta(p_z - vm_y/c), \\ &\mathrm{M}_X = m_x, \quad \mathrm{M}_Y = m_y/\beta, \quad \mathrm{M}_Z = m_z/\beta, \end{aligned} \qquad \text{(iv)}$$

and in addition we must have these equations for current and density

$$\mathrm{R} = \beta(\rho - vj_x/c), \quad \mathrm{J}_X = j_x/\beta, \quad \mathrm{J}_Y = j_y, \quad \mathrm{J}_Z = j_z. \quad . \quad \text{(v)}$$

Minkowski employs no theory as to the constitutive nature of P, M, J, R. If now we assume any equations we please connecting E, B, P, M, J, R for a body at rest as characteristic of the matter in question, these may by means of (ii), (iv), and (v) be translated into equations connecting e, b, p, m, j, ρ. These relations according to the theory of relativity are the constitutive equations for moving bodies.

The P, M transformations have been obtained without any view to electron or any other theory; but if the Lorentz theory is mathematically

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[4] *Gött. Nachr.*, 1908, pp. 1–59.

correct and R, J, P, M are expressible in terms of the position and motions of charges, these should follow by mere application of the geometrical transformations for space and velocity, and this has in fact been shown to be so.

6.

Generalised Relativity.

We may note at this point that we have not examined how far the possibilities of this relativity extend. We have only investigated space-time transformations of one special form. Are these the only possible ones? Let us take the fact that light is propagated equally in all directions with velocity c, and examine what possible changes in the measures of time and space would be allowable in order that this property might be preserved. We are to have

$$\delta S = c\delta T$$

a consequence of

$$\delta s = c\delta t$$

for all directions of δs through all points.

We must, therefore, allow only of such transformations as give

$$\delta x^2 + \delta y^2 + \delta z^2 - c^2\delta t^2 = \phi(x, y, z, t)\,(\delta x^2 + \delta y^2 + \delta z^2 - c^2 T^2).$$

Putting $ict = u$, $icT = U$, we must have

$$\frac{\delta X^2 + \delta Y^2 + \delta Z^2 + \delta U^2}{\delta x^2 + \delta y^2 + \delta z^2 + \delta u^2} = \phi$$

independently of the ratios of $\delta x : \delta y : \delta z : \delta u$, *i.e.*, the transformation would be a conformal one in space of four dimensions in which x, y, z, u were co-ordinates. It has been proved that such transformations are compounded of two kinds only, viz.:

(i) Generalised rigid body motions, *i.e.*, translations and rotations, or motions which leave all lengths unchanged.
(ii) Inversions in what we may call four dimension spheres.

Of these a translation is merely a changing of origin, while a rotation leads to the above transformations.

The simplest transformation of the form (ii) is

$$X = \frac{k^2 x}{r^2 - c^2t^2}, \qquad Y = \frac{k^2 y}{r^2 - c^2t^2}, \qquad Z = \frac{k^2 z}{r^2 - c^2t^2}, \qquad T = \frac{k^2 t}{r^2 - c^2t^2},$$

and a transformation has been developed for the electromagnetic equations which is at all points analogous to that above outlined.

We have reason, therefore, to suppose that a uniform motion of translation is not the only one which would be concealed in an electromagnetic field. The only reason that attention has been mostly confined to the simpler case, is that nothing in Newtonian dynamics could suggest the more complex one.

The chief point at the present moment is that we have exhausted the possible chances of complete relativity without arriving at any transformations corresponding to a motion of rotation or accelerated motion of a

system. Thus, for instance, the magnetic effect of a rotating electrified sphere would be observable by instruments carried round with the sphere: they would not be obscured by the fact that the recording instruments shared in the rotational motion.

7.

Mechanics and Relativity.

In the light of the principle of relativity there are some interesting aspects of the status of the old dynamics.

If v^2 is neglected the space-time transformation of relativity reduces to what was called above a Newtonian transformation. The suggestion arises; supposing relativity to be a universal hypothesis, what knowledge does it give concerning molar dynamics? Is Newtonian dynamics an approximate science in which we are consistently neglecting v^2? Can we formulate a more exact scheme conforming to the principle and reducing for small molar velocities to that of Newton? What modified meaning must be attached to the words *mass, momentum, kinetic energy.*

An illustration may be given of the kind of modification that will be necessary.

Let us suppose that a conventional material particle carrying a charge ϵ is at rest in an electric field. It will begin to move with an acceleration which would ordinarily be determined by equations

$$m\frac{dX}{dT^2} = \epsilon E_x, \qquad m\frac{d^2Y}{dT^2} = \epsilon E_y, \qquad m\frac{d^2Z}{dT^2} = \epsilon E_z,$$

taking (X, Y, Z, T) as the space-time system in which it is initially at rest.

Applying the transformation, the same motion is represented by the equations

$$\frac{d}{dt}\left(\frac{m\frac{dx}{dt}}{\sqrt{1-w^2/c^2}}\right) = \epsilon e_x,$$

$$\frac{d}{dt}\left(\frac{m\frac{dy}{dt}}{\sqrt{1-w^2/c^2}}\right) = \epsilon\left(e_y + \frac{v}{c}h_z\right),$$

$$\frac{d}{dt}\left(\frac{m\frac{dz}{dt}}{\sqrt{1-w^2/c^2}}\right) = \epsilon\left(e_z - \frac{v}{c}h_y\right).$$

where w is the total velocity of the particle (having components

$$\frac{dx}{dt}, \frac{dy}{dt}, \frac{dz}{dt},$$

whose instantaneous values are v, o, o). These equations contain the theory of the results of the experiments of Kaufmann and Bucherer on the variability of the accelerations of electrons moving with different velocities in the same field.

If we choose to call the vector

$$\frac{mw}{\surd(1 - w^2/c^2)}$$

the *momentum* of the particle and to call

$$\epsilon e_x, \quad \epsilon\left(e_y + \frac{w}{c} h_z\right), \quad \epsilon\left(e_z - \frac{w}{c} h_y\right)$$

the *force* acting on the particle, the above equations express that the *force is equal to the rate of change of the momentum*, but the momentum is not proportional to the velocity unless we neglect quantities of relative order (w^2/c^2).

We may from these equations obtain another

$$\frac{d}{dt}\left\{\frac{mc^2}{\surd(1 - w^2/c^2)}\right\} = \mathrm{K}_x \frac{dx}{dt} + \mathrm{K}_y \frac{dy}{dt} + \mathrm{K}_z \frac{dz}{dt}$$

where K is the vector above called the *force*.

If, again, we choose to call

$$\frac{mc^2}{\surd(1 - w^2/c^2)}$$

the *energy* of the particle, we have a generalised energy equation, and neglecting higher powers of w/c the energy is $mc^2 + \frac{1}{2}mw^2$ which differs from the energy of Newtonian theory only by a constant. No hypothesis has been made here as to the nature or origin of m.

We may consider a little more closely the question of the so-called electromagnetic momentum and energy. Einstein[5] considers a system subject to no external constraint such as we might imagine an electrically constituted atom to be, its configuration being determined by internal action alone, and, supposing it to take up energy from incident radiation, shows that the electromagnetic energy taken up when the system is supposed to be in motion is β times the energy taken up when it is considered to be at rest. Supposing that part of the energy is given up to moving particles after the fashion just described, we have exactly a similar result for the corresponding amounts.

Thus we have the result:—

$$\mathrm{E} = \frac{(m + \mathrm{E}_0)c^2}{\surd(1 - w^2/c^2)},$$

and further it appears that, if a similar calculation is made for momentum

$$\mathrm{G} = \frac{(m + \mathrm{E}_0)w}{\surd(1 - w^2/c^2)}.$$

Thus it would appear that, as far as the mechanical equations go, it is only $(m + \mathrm{E}_0)$ that matters, and m might even be zero.

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[5] *Jahrb. d. Radioakt. und Elektr.*, 4, 1907.

It appears from these equations that there is an intimate connection between the internal energy of a system and its inertia in the Newtonian sense. A mass m corresponds to energy mc^2. Even the enormous stores of energy exhibited by radio-active bodies represent only a small fraction of the energy suggested by this equation.

8.

We have seen that the principle of relativity may be used to obtain from known phenomena in a given system the corresponding phenomena in the same system when supposed to be as a whole in motion with a uniform velocity of translation. But we cannot determine by means of the principle the influence of a system A upon a system B, when B is moving relative to A, from a knowledge of that influence when they are relatively at rest. This fact is closely associated with the fact that events which are simultaneous to one observer are not simultaneous to another.

The following example will illustrate this:—

Suppose two points A B to move along a straight line. When they are relatively at rest let the acceleration of B towards A be $f_B (x_B - x_A)$ and let that of A towards B be $f_A (x_B - x_A)$, as measured by an observer at rest relative to them both.

We have seen that when they are both moving with velocity v along the line their accelerations will be f_B/β^3, f_A/β^2.

Suppose, however, we seek to deduce the accelerations when A has a velocity v_A and B a velocity zero relative to a given observer.

The acceleration of B must be of the form $F_B (x_B, x_A, 0, v_A)$, and is such that

$$F_B (X_B, X_A, V_B, V_A) = F_B (x_B, x_A, 0, v_A)/\beta^3 \quad . \quad . \quad (a)$$

where

$$v_A = \frac{v_A + v_B}{1 + \frac{v_A v_B}{c^2}}.$$

If we are given the function $F_B (x_B, x_A, 0, v_A)$ for all values of v_A then we can therefore deduce the function for all values of v_B, but if we are only given $F_B (x_B, x_A, 0, 0)$ this is impossible.

Suppose we could determine any one function satisfying (a) then we could determine any number of others by multiplying F by any quantity which is the same function of (x_B, x_A, v_B, v_A) as of (X_B, X_A, V_B, V_A). Of such invariants an infinite number can be found, so that the principle of relativity affords only a certain means of discrimination between possible and impossible forms of F_A and F_B, but not a means of unique determination.

All that the principle can do, for instance, in respect of the law of gravitation is to say that the Newtonian Law cannot be exact, and to suggest an infinite number of possible ways of rendering it so. Of course, if gravitation is to be included in an electromagnetic scheme of matter, we must expect it to be an effect propagated through the æther with the velocity of light. If, on the other hand, it has nothing to do with the electromagnetic properties of matter, we shall hardly expect it to conform to the principle of relativity. Just as the Newtonian dynamics breaks down in the light of the electrical theory, so the latter may become only an approximation, if gravitation is concerned with more remote and yet undiscovered properties.

9.

It becomes, therefore, a question of great interest to ask whether experiment can say anything about gravitation in the light of the theory of relativity. Poincaré[6] has shown how to obtain modified laws conforming to the principle of relativity, and de Sitter[7] has examined two of these in the light of the effect they would have on the planetary orbits.

The equations proposed in place of the ordinary equation

$$\frac{d^2x}{dt^2} + \frac{kx}{r^3} = 0$$

are

$$\frac{d^2x}{d\tau^2} + \frac{kx}{r^3} = 0 \quad . \quad . \quad . \quad . \quad \text{(I.)}$$

and

$$\frac{d^2x}{dt\,d\tau} + \frac{kx}{r^3} = 0, \quad . \quad . \quad . \quad . \quad \text{(II.)}$$

where τ is a new variable connected with t by the relation

$$\frac{d\tau}{dt} = \sqrt{1 - v^2},$$

v being the velocity of the planet relative to the sun at time t.

The analysis shows that neither of these leads to any observable periodic or secular change in the orbits, except in the case of Mercury, where it would give rise to a motion of the apse line which would be within the reach of modern measurements were it not concealed in a larger motion of the same kind attributed to a different cause. It would, of course, in the light of what has been said, be possible to invent any number of alternatives to I. and II. which would lead to perturbations of easily appreciable magnitude, but the important outcome of de. Sitter's discussion is that existing astronomical data place no obstacle in the way of gravitational phenomena being included within the scope of the hypothesis of relativity. The laws given above assume a velocity of propagation for gravitation equal to that of light, such as had for a long time been thought an impossible assumption.

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[6] *Rend. del circ. mat. de Pal.* xxi., p. 129.

[7] *Monthly Notices Roy. Astr. Soc.*, lxxi. 5.

Stellar Distribution and Movements. *By* A. S. EDDINGTON, *M.A., M.Sc.*

[Ordered by the General Committee to be printed *in extenso.*]

THE last few years and perhaps especially the last twelve months have brought to light many new facts bearing on the question of stellar distribution and movements. The advance must be attributed principally to the greatly improved data that have recently become available for discussion. When the data of proper motions, of radial velocities, and of parallaxes now at hand are compared with what existed ten years ago, there is found an evident reason for what might otherwise appear to be a sudden outbreak of activity in this branch of research. We are now to take stock of the new facts and of the old, and try to see to what conception of the structure of the universe they lead; whilst new results are continually being obtained and theories are in a fluid state, this is a task of some difficulty; but it is at a time like the present that a general discussion of the subject may be especially useful.

Let me begin by presenting an outline of the universe as it is revealed by modern researches; the details will follow later. First, it is believed that the great mass of the stars, excluding the Milky Way, are arranged in the form of a lens or bun-shaped system. Our sun occupies a nearly central position, or at least a position midway between the two flattened surfaces. The thickness of this system, though enormous when compared with ordinary units, is not so great but that our telescopes easily detect the absence of stars beyond. We cannot specify the thickness definitely, because there is no definite boundary, but only a gradual thinning out in the number of stars. The plane of the lens-shaped system is the same as the plane of the Milky Way, so that when we look towards the galactic poles we are looking towards the parts where the boundary is nearest to us; looking along the galactic plane; we are looking towards the perimeter of the lens, where the boundary (or thinning out of the stars) is most remote, though probably not beyond the penetrating power of our telescopes.

Near the sun the stars seem to be distributed in a fairly uniform manner, or rather, there are irregularities, but they are on a small scale; but in the remoter part of the lens, or perhaps right beyond it, we come across the great cluster of series of star-clouds which make up the Milky Way itself. I think that is a right distinction. There are two quite separate phenomena associated with the galactic plane which have sometimes been confused. Firstly it is the plane in which the Milky Way star-clouds are coiled, and secondly it is the median plane of the lens-like arrangement of the nearer stars.

In studying the movements of the stars, we have perforce to leave out the remoter parts of space and confine attention mainly to stars of the central system, and perhaps only the inner parts of it, where the apparent movements are appreciable. The remarkable result appears that the stars move with a strong preference in two opposite directions in the galactic plane. As Professor Kapteyn showed at the British Association meeting in 1905, there are two favoured directions of motion; and I believe there is moderately good evidence that this is caused by two aggregates of stars of more or less independent origin passing through each other, and so, for the time, being completely intermixed. Be that as it may, there can be no doubt that one particular line in the galactic plane is singled out; the stars move to and fro along it in preference to any transverse direction. It is a significant fact that the line lies in the galactic plane; it establishes some kind of connection between the phenomena of stellar distribution and the phenomena of stellar motion; but the relation is of an unexpected character, and is not easy to interpret.

We must in passing take note of the 'Moving Clusters,' which have lately attracted attention. These are groups of stars possessing equal and parallel velocities though often widely separated in space. The most important is the Taurus cluster,[1] which contains about forty known members. Of the others, the Ursa Major stream[2] now known to be by no means confined to the one constellation, has about thirteen members; a Perseus cluster[3] of Helium stars has seventeen members, and there is a very large but ill-defined moving cluster in Scorpius. In each cluster the component stars move with practically identical velocities, as it were ignoring the other non-cluster stars, which are actually interspersed between them. The chief interest of these clusters lies in the fact that in the case of the Taurus and Ursa Major groups their peculiarity of motion has afforded an unexpected means of determining their distances and absolute luminosities; we thus obtain precise knowledge about stars which are far too remote for the ordinary methods of measurement to be successful. These clusters however also throw an interesting light on the great problem of the origin of the individual velocities of stars, as we shall see later.

There is a whole class of stars, those of the Orion or Helium type of spectrum, which stand out exceptionally. These seem not to share in the motions of the two star-streams, and in fact have very little motion of any sort, either individual or systematic. They are known to be stars of enormous intrinsic brilliancy, so that a large proportion of those visible to us are very far away; perhaps the fact that most of them lie beyond the part of the universe we generally consider in discussing stellar motions explains why their movements are exceptional. Those Orion stars that are nearest have a great tendency to form moving clusters, such as those of Perseus, Scorpius, the Pleiades, and

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[1] L. Boss, *Astron. Journ.*, No. 604.

[2] Ludendorff, *Ast. Nach.*, No. 4313–14; Hertzsprung, *Astrophysical Journal*, xxx., p. 135.

[3] Benjamin Boss, *Astron. Journ.*, No. 620; Eddington, *Monthly Notices*, R.A.S., lxxi., p. 43.

the constellation Orion itself. In some cases at least, in Orion and the Pleiades, they are set in a diffused nebulosity of enormous extent.

Another phenomenon associated with spectral type, of which these Orion stars show the extreme case, is perhaps the strangest result of all. Astrophysicists have arranged stars by their spectra, in what they believe to be the successive stages of evolution. Now it has been recently found that stars of an early type of spectrum, that is in an early stage of evolution, have much slower individual motions than those in a later stage. It seems as though a star is born with no motion at all and gradually acquires or grows one.

This concludes my first rapid survey of the subject and we must now look at some of the details more closely. In considering the distribution of the stars we may very well begin by taking those in our own immediate neighbourhood. We will start from the sun as centre and take a sphere ninety-five billion miles in radius, roughly a million times the radius of the earth's orbit. This will contain what is probably a normal though rather a small sample of the stars. The table, for which I am indebted to the Astronomer-Royal, gives all the stars known to be inside that sphere; they are seventeen in number, or eighteen counting the sun.

The Seventeen Nearest Stars.

(Stars distant less than 95,000,000,000,000 miles from the sun.)

Star	Magnitude	Spectrum	Parallax	Luminosity (Sun = 1)	Remarks
Gr. 34	8·2	Ma	·28	0·010	binary
η Cassiopeiæ	3·6	F8	·20	1·4	binary
τ Ceti	3·6	K	·33	0·5	—
C.Z.5.^{h}243	8·3	—	·32	0·007	—
Sirius	−1·6	A	·38	48	binary
Procyon	0·5	F5	·32	9·7	binary
Lal. 21185	7·6	Ma	·40	0·009	—
Lal. 21258	8·9	Ma	·20	0·011	—
O.A. 11677	9·2	—	·20	0·008	—
α Centauri	0·3	G, K5	·76	2·0 0·6	binary
O.A. 17415	9·3	F	·27	0·004	—
P.M. 2164	8·8	K	·29	0·006	binary
σ Draconis	4·8	K	·20	0·5	—
α Aquilæ	0·9	A5	·24	12·3	—
61 Cygni	5·6	K5	·31	0·1	binary
ε Indi	4·7	K5	·28	0·25	—
Krüger 60	9·2	—	·26	0·005	binary

There may be a few others that have not yet been found, but I think it is unlikely that more than two or three have escaped detection, unless they are bodies of very feeble luminosity. Of course, we cannot base extensive generalisations on so small a table, but I shall use it to illustrate conclusions which are in reality based on more elaborate researches. First, it gives a measure of how tightly the stars are packed. Think of a globe of space whose circumference is the earth's orbit, then think of a volume a million million million times greater;

such a space would contain about eighteen stars. Further, we notice that eight stars out of the eighteen are binaries. I daresay that that proportion may be higher than the average; still, there is good evidence that double stars form a large fraction, perhaps a third, of the whole number of stars.

The intrinsic luminosities of these stars vary from forty-eight times to less than one-hundredth that of the sun. Naturally, a larger sample would give a greater range; probably there exist (very rarely) stars giving as much as ten thousand times the light of the sun. We see further that there are five stars more luminous and twelve stars less luminous than the sun, so that the sun stands well above the average; this also is confirmed by more elaborate investigations. Turning to the types of spectrum, it is at first rather astonishing to find that three of the stars are of the Third Type (Type M), because in the catalogues stars of this type are rather rare—less than a fifteenth of the whole number of stars. All three of these M stars are very faintly luminous, and this fact leads to an explanation. We infer that M stars are really very abundant everywhere, but they are too faint to be seen, except when they are near to us, and consequently not many appear in the catalogues. The Orion Type stars (Type B) are rather more numerous than the M stars in the catalogues, but there is not a single one in this list. The same explanation holds. Orion stars are really very rare in space, but they are exceedingly bright, and can be seen a long distance away, so that they are recorded in numbers out of all proportion to their actual frequency in space.

This illustrates a rather important conclusion. The proportions of the different types of stars, as seen in the sky or as recorded in the catalogues, is utterly misleading as an indication of their relative abundance in space.

Parallax-measuring carries us only a very short way into the vast system of stars surrounding us. Of course, the short table given does not exhaust all that is to be learnt from measured parallaxes. There are now some three hundred and sixty stars for which more or less trustworthy determinations have been made,[4] but these include a great many for which the result is practically zero. In parallaxes of a tenth of a second and under the error of determination becomes relatively important, and these smaller parallaxes do not give much certain information about particular stars; they are, however, very important for statistical analysis, and much statistical work must ultimately rest on the measured parallaxes as a basis.

To go beyond the small fringe of stars which is sounded by our parallax determinations we must examine statistics of magnitudes and motions. Now the prominent fact that appears from counts of the numbers of stars down to definite magnitudes is the great crowding to the plane of the Milky Way; and this following Herschel, we explain as being due to the flattened form of our stellar system. The crowding shows a continuous increase from the galactic poles to the equator, and seems to be uniform and symmetrical. Along the galactic equator there

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[4] Kapteyn and Weersma, *Groningen Publications*, No. 24.

is the Milky Way itself, which introduces a complication and exaggerates in an irregular manner the already great star-density. But in the main the concentration cannot possibly be attributed to the Milky Way, which obviously can only be responsible for the star-density in the very limited belt in which it lies.

There is a very important theorem in stellar distribution which seems to have been known for a long while, but I do not know who originated it. If in any direction the stars are uniformly distributed, as far as the instruments will penetrate, then the number of stars of one magnitude is four times the number a magnitude brighter (more precisely, the ratio is 3·98). This allows for the fact that individual stars are of all degrees of intrinsic brightness; it only requires that the mixture of big and little stars should be in the same proportion everywhere. If this holds, and the stars extend uniformly for an unlimited distance, then there will be four times as many eighth as seventh magnitude stars, and so on.

Now it is well known that this *star ratio*, as it is called, falls far short of its theoretical value. I give a table of the star ratio based on Kapteyn's work.[5] Even in the galactic plane it is much below the theoretical limit, and towards the poles it is even smaller. An obvious interpretation is that the star-density falls off at some distance from the solar system, and that the falling-off is more pronounced at the galactic poles than near the equator; this leads to the conception of the bun-shaped system already described. To give some idea of the extent and scale of the system the following may serve: A sphere of radius corresponding to a parallax 0″·2 was found to contain eighteen stars. Within a sphere of ten times the radius (parallax 0″·02) there is no appreciable falling-off in density; but now multiply by ten again (parallax 0″·002), and towards the galactic poles you will reach a region almost void of stars, whilst in the galactic plane the falling-off in density will probably be appreciable, unless, indeed, you have reached the star-clouds of the Milky Way itself.

Star Ratios.

Galactic Latitude	Magnitude. 7·0 – 8·0	Magnitude. 12·0 – 13·0
0°	3·21	2·88
15°	3·05	2·71
30°	2·94	2·47
40°	2·87	2·32
60°	2·79	2·05
90°	2·76	1·85

These star-magnitude statistics at present suffer very much from the absence of reliable standards of magnitude for the faint stars. Thus the figures for the star ratio given in the table are open to considerable doubt from that cause. We are, however, confident that that difficulty will soon be removed, and the data will be vastly improved. The work of Professor Schwarzschild on the brighter stars, and Professor

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[5] *Groningen Publications*, Nr. 18.

Pickering's standard sequences running down to the faintest magnitudes now provide an excellent basis for work. At Greenwich a large programme of photometry is being carried out, based on Pickering's standards, and may be expected to provide improved statistics, which will be available in a year or two.

Reference is often made to the phenomenon that certain classes of stars do and others do not crowd towards the galactic plane. For example, stars of the solar type of spectrum do not show the tendency to congregate towards it, whereas stars of the Orion type are found almost exclusively in it. These differences admit of an easy explanation; everything depends on whether the class of stars coming into consideration extends sufficiently far. If we take a class of feebly luminous stars, or if we take the stars of large proper motion, we necessarily limit ourselves to stars which are near the sun; there is no reason why *they* should be most numerous near the galactic plane. If, however, we take a class of stars which extend and are bright enough to be seen a long way, then the bun shape of the universe makes itself apparent. Clearly it is only if the class of stars extends to the limits of the stellar system that the shape of those limits can affect the apparent distribution.

One further question: where does the Milky Way begin? Do its clusters consist entirely of faint stars or are some of the bright stars actually in it? The answer seems to be given clearly enough by Newcomb.[6] By counting the abundance of the bright stars in the parts of the sky where the Milky Way is bright, and again in the faint portions and openings, he concludes that even stars brighter than the sixth magnitude are associated with it; they are sparse or dense according as the Milky Way is faint or concentrated. It seems at first difficult to reconcile the existence of naked-eye stars in the Milky Way with the remote position we have assigned to it, but I do not think there is any contradiction. Modern views admit a very wide difference in the intrinsic brightness of stars, and even if the parallax of the Milky Way is 0″·001 we might still expect it to contain stars (probably of the Orion type) which are visible to the naked eye.

We now turn from the distribution to the motions of the stars,[7] and in particular to the two star-streams found by Kapteyn. Our knowledge of stellar motions refers principally to the nearer parts of the universe; but it is really very difficult to say to what part of the stellar system the results of any investigation apply. Any particular catalogue of proper motions includes a fairly compact bunch of near stars together with a 'ragged edge' of enormous extent. It is one of the questions for future research, How far do the two star-streams extend into space? Any estimate that I can give now would be only a rough guess; but I should think that at least half-a-million stars belong to the two streams.

The first researches on the star-streams were based on two important

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[6] *The Stars: a Study of the Universe*, p. 260.

[7] The first clear recognition that the motions of the stars deviated considerably from a haphazard distribution is found in the researches of Kobold; he moreover detected a relation of the systematic motions to the galactic plane.

catalogues of proper motions—namely Auwer's Bradley and Dyson and Thackeray's Groombridge catalogue. A great opportunity for advance has recently been afforded by the publication last year of a series of over six thousand very accurately determined proper motions distributed all over the sky—Professor Boss's Preliminary General Catalogue. This new and specially favourable material for analysis confirms in the main the results previously reached. Analysing the data on the two-drift theory,[8] it is found that approximately three-fifths of the stars belong to Drift I. and two-fifths to Drift II. Drift I. is moving with a velocity of 1·52 towards R.A. 90°·8, Dec. −14°·6; and Drift II. with a velocity of 0·86 towards R.A. 287°·8, Dec. −64°·1, the velocities being measured in terms of the theoretical unit $1/h$ usually employed in this work. These are the motions relative to the sun. The vertex or direction of the line of relative motion of the two drifts is R.A. 94°·2, Dec. +11°·9, very near to the position which Kapteyn originally announced. The bipolarity of the motions is shown most plainly in the data, and the results from the different parts of the sky are in excellent accordance with one another.

It is convenient for the purposes of explanation and for mathematical analysis to represent this bipolarity in the stars' motions as being the result of two systems of stars having become intermingled. I think there is much to be said in favour of this view; but, as Professor Schwarzschild has well shown, it goes beyond what the observations strictly entitle us to assert. By putting together two systems moving in different directions a good representation of the phenomena is obtained, but a good representation can also be obtained in which the duality is not evident. The ellipsoidal hypothesis of Schwarzschild[9] regards the stars as forming a single system, although it represents the streaming in two favoured directions. More recently Dr. Halm[10] has introduced the idea of a third drift in order to obtain a closer approximation to the observations. Our theoretical ideas as to the mode of origin of this curious bipolarity of the stellar motions—whether we must divide the stars into one or two or three systems—will probably depend on which of these representations gives the closest account of the observed motions; but, neglecting these ulterior considerations, the distinction between these theories is surprisingly small.

Let us examine a little more closely what it is that we wish to find out. Our immediate goal is, I think, to be able to state a frequency law of star motions. Just as Maxwell's law states how many molecules of a gas have a given velocity (u, v, w), we require a law stating how many stars have any specified linear velocity. Such a law need not in the first place be a mathematical expression; it may be embodied in a numerical table or a diagram; but if we could obtain this information in some form we could afterwards decide whether it corresponded most nearly with the formulæ of the two-drift, ellipsoidal, or some other theory. The materials of observation are the *proper* or angular motions

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[8] Eddington, *Monthly Notices*, lxxi., p. 4.

[9] *Göttingen Nachrichten*, 1907, p. 614.

[10] *Monthly Notices*, lxxi., p. 610.

of the stars; we can without difficulty construct tables or diagrams to show how they are distributed. We have to deduce from these the distribution of the *linear* velocities, without assuming that the law is ellipsoidal, two-drift, or of any other special form. After listening to Professor Turner's presidential address to this Section, I feel sure that this is precisely the mode of investigating such a problem which he especially advocated.

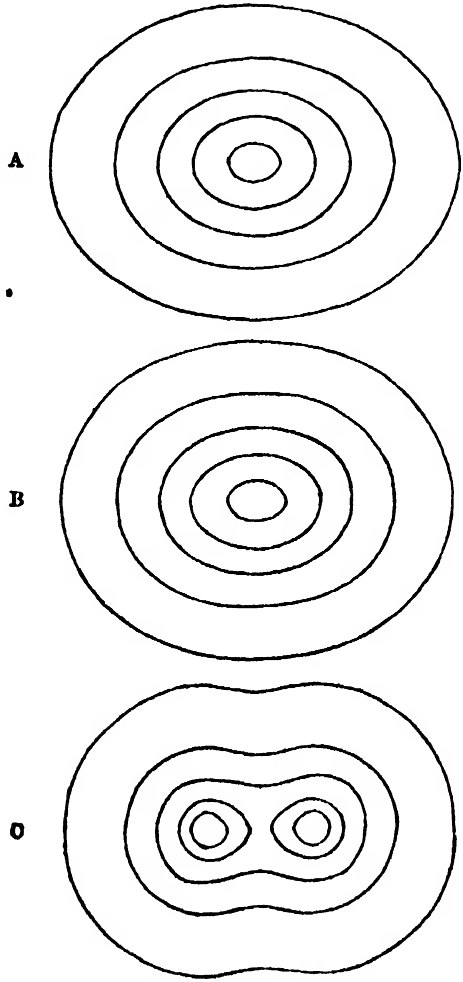

Diagram showing the Theoretical Curves of equal frequency of Stellar Velocities.
A. Ellipsoidal Theory. B and C. Two-drift Theory.

Let us construct in imagination a diagram of velocities. Considering

for simplicity two dimensions only, we can represent each stellar motion by a dot whose co-ordinates represent the two components of the velocity. All the theories agree that the dots would be arranged in an elongated distribution—elongated along the line already referred to along which the stars move in greater numbers, one stream towards one end, and the other towards the other end. But the different theories do not agree in the detailed arrangement of the dots. We can summarise the dot-diagram in a more convenient way; we can draw contour lines to specify the density of the dots—*i.e.*, mark out places on the diagram where the dots are equally thick. That is perhaps the most illuminating way of stating a frequency law. In the diagram I compare the two-drift and ellipsoidal theories by their contour lines—lines which indicate what values of the (linear) stellar velocity occur with equal frequency. For the ellipsoidal theory there are similar ellipses (fig. A). Those for the two-drift theory are less simple curves, and rather curiously they may take two different forms (figs. B and C), according to the precise values of the arbitrary constants. There may be two points of maximum frequency or only one point. The central figure B is especially interesting, because it shows that even if there are two distinct streams we may find no indication of a separation of the dots into two groups. Actually the values of the drift motions are such that it is uncertain whether we should find the contours of the form B or of form C; they are near the critical values. The especial matter to which I would call attention is that A and B represent the distribution of velocities for different theories of the universe; A treats the universe as a single system and B divides it into two.[11]

To determine these contour lines from the observations is a mathematical problem of some difficulty. Without going into detail, it comes to solving a certain integral equation. The equation in question is one that is theoretically soluble, and a quite similar one occurring in another branch of stellar statistics has been elegantly treated by Schwarzschild.[12] As applied to the present problem, however, there are difficulties in obtaining a convergent solution which have not yet

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[11] Some further information as to these diagrams may be of interest. For both A and B the contours are drawn for the same values of the density, viz., 0·96, 0·83, 0·64, 0·38, 0·13, taking the density at the centre as unit. A is for a Schwarzschild ellipse in which the ratio of the axes is 0·77. B is for two equal drifts whose relative velocity is equal to the quantity $\frac{1}{h}$, which in the mathematical theory gives a measure of the average individual velocities. C is for two equal drifts whose relative velocity is $\frac{2}{h}$; for convenience C has been drawn on half the scale of B, so that the relative drift velocity is represented by the same length in both figures; the contours are drawn for the relative densities 0·9, 0·75, 0·4, 0·1, 0·001. The critical case arises when the relative velocity of the two drifts is equal to $\sqrt{2}/h$, if the drifts are equal; if, as actually occurs, the number of stars in the two drifts is unequal this will be modified. The actual distribution in the sky is decidedly more elongated than that shown in A and B; in selecting constants for B, I wished not to approach too near the critical case. It may be noted that A and B are practically indistinguishable when drawn on this scale; the only difference that can be detected is that the outermost ellipse of B is slightly less eccentric than that of A.

[12] *Ast. Nach.*, No. 4422.

been overcome (the solution is divergent except under very special conditions). I may mention, however, that I made a rough preliminary solution, which avoided the difficulties of divergency. Much to my surprise, the contour lines for this solution showed two points of maxima and generally resembled the figure C (or rather figure C modified by assuming two drifts containing unequal instead of equal numbers of stars). It is hard to say how much weight should be attached to this rough result; my attempts to make a closer and really trustworthy solution have up to now been unsuccessful.

Mean Radial Velocities.[13]

(After correcting for the 'Solar Motion.')

Angular Distance from the Vertex	Mean Radial Velocity	Weight (No. of Stars)
0°-30°	16·1	74
30°-60°	14·0	164
60°-90°	12·6	249
90°-120°	12·9	259
120°-150°	14·0	219
150°-180°	15·7	80

The phenomenon of streaming in two favoured directions has now been detected in the radial motions by Hough and Halm, and by Campbell. Radial motions are rather awkward to work with, because, if you wish to compare motions in two particular directions, you cannot use stars in the same part of the sky, but must compare those parts of the sky for which the directions in question are radial; this sometimes introduces a complication. The table, however, shows that near the vertex and anti-vertex (towards which the two favoured directions point) the motions are greater than midway between them; this means that motions in the supposed directions of the streams are on the average greater than those transverse to them, and thus confirms the theory. The difference is not so great as would be expected from our other knowledge of the stream motions; but there seems to be a satisfactory explanation of this. The vertices lie exactly in the plane of the Milky Way, a part of the sky where early type stars are especially abundant. As already mentioned, these have individual motions considerably smaller than the later type stars, and so the average is unduly lowered in the neighbourhood of the vertices. I think this fully explains why we do not find so big a difference as might have been expected. The variation depending on position in the sky has not been separated from the variation depending on direction of motion, and the one partially counterbalances the other.

The exceptional character of the motions of the Helium or Orion stars, which was first discovered by Frost and Adams[14] has been the subject of several important investigations. Very recently Campbell[15]

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[13] Campbell, *Lick Obs. Bull.*, No. 196, Table IV.
[14] *Yerkes Observatory Publications*, vol. ii., p. 105.
[15] *Lick Obs. Bull.*, No. 195.

has shown that the hitherto measured radial velocities of these stars are all subject to a systematic error of about 5 km. per second, which may arise from a pressure-shift of the spectral lines. In the light of this discovery some of the results will probably need revision. However, the main fact is not disturbed, but rather emphasised; Orion stars have very small individual motions and do not share in the star-stream motions to any appreciable extent. This latter fact is the more curious, because it is the next type in order of evolution, Type A, that shows the star-streaming in its purest form. Dyson[16] found that these stars diverge very little from the general directions of the drifts to which they belong, a fact which accords with their low individual velocities, which should leave the drift-motions predominant. On the other hand, my results from the examination of Boss's catalogue, and Halm's[17] more detailed investigation, indicate that there are some other stars (of what type has not been ascertained) that share with the Helium stars the peculiarity of being nearly at rest and not belonging to the two streams. These stars, which Halm has called Drift O, are, like the Helium stars, concentrated towards the galactic plane—a fact which, as we have seen, usually indicates remoteness. The vast distance of the Helium stars appears to me so fundamental a fact in considering this subject, that I will quote in support Prof. Boss's conclusion.[18] He finds that a space around the sun having a radius corresponding to parallax 0″·015 is 'almost wholly devoid of these stars.'[19] It is not necessary to conclude that the part of space round our sun is unusually bare of Helium stars; I would rather suggest that they are extremely rare everywhere (except in certain moving clusters), but that owing to their brightness they are visible at, say, ten times the distance of an ordinary star, and therefore throughout a volume of space a thousand times as great. In any case the exceptional behaviour of the Helium stars now becomes explicable; they do not conform to the two star-streams because they lie beyond the region of space through which the star-streams prevail. Similarly, I think it is likely that in the Drift O stars we have to deal with remote stars beyond the limits of the star-streams; but there is no direct evidence on this point.

I must pass briefly over another subject to which I alluded in my preliminary survey—the Moving Clusters. A question of general interest is, Are they similar to the star-clusters ordinarily so called, the distinction being that the moving clusters are much nearer to us? Prof. Boss has shown that in the far future his Taurus cluster will appear as a small globular cluster. On the other hand, Prof. Turner has called attention to the remarkable fact that in the Ursa Major stream, and probably also in the Perseus stream, the stars lie very nearly in a plane. One would certainly have supposed that the ordinary star-clusters must contain the stars much more closely

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[16] *Proc. Roy. Soc. Edinburgh*, xxix., p. 390.

[17] *Monthly Notices*, lxxi., p. 620.

[18] *Astron. Journ.*, Nos. 623–24.

[19] This space would, arguing from the sample eighteen stars round the sun, contain at least 40,000 stars.

concentrated than is the case in the moving clusters, where they appear to be at ordinary stellar distances. The question must be left open. Another peculiarity, which can hardly be considered here, but which reminds us how exceedingly complicated is the problem we are trying to unravel, has been found by Hinks[20]; according to his investigations practically all the globular clusters are concentrated into one-half of the celestial sphere.

A great interest is added to the problem of stellar motions by the discovery, actually made last year, but foreshadowed for several years, that the stars of the later types of spectrum have larger individual motions than those of earlier types. The table gives the most complete evidence—that of Campbell; it confirms an earlier table by Kapteyn,[22] and Boss[23] has also found confirmatory evidence from the angular motions. Properly considered, I think that this relation of spectral type and velocity is one of the most startling of the results of modern astronomy. For the last forty years astrophysicists have been studying the spectra and forming their systems by which they arrange the stars in order of evolution. However plausible may be their arguments, one would have said that their hypotheses must be for ever outside the possibility of confirmation. Yet if this result is right, we have a totally different criterion by which the stars are arranged in the same order. If it is really true that the mean motion of a class of stars measures its progress along the path of evolution, we have a new and powerful aid to the understanding of the steps of stellar development.

Mean Velocities of Stars.[21]

Type of Spectrum	Radial Velocity. Km. per sec.	Weight (No. of Stars)
B	6·52	225
A	10·95	177
F	14·37	185
G	14·97	128
K	16·8	382
M	17·1	73
planetary nebulæ	25·3	12

The facts now brought before us direct attention to the very deep-lying question, How must we account for the individual motions of the stars? It appears that as we trace back the life-history of a star, its velocity is found to be smaller and smaller; in the Orion stage it was only about one-third of what it will ultimately become. It seems right to infer that the stars are born with little or no individual motion. Assuming that the gravitational action of other stars is responsible for the motion subsequently accumulated, this might be thought to point to stars being developed from a primordial matter not subject to

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[20] *Monthly Notices*, lxxi., p. 693.
[21] Campbell, *Lick Observatory Bull.*, No. 196.
[22] *Astrophysical Journ.*, xxxi., p. 258.
[23] *Astron. Journ.*, No. 623–24, p. 198.

gravitation. But that certainly unwelcome assumption is by no means necessary. A star is presumably formed by the lumping together of the meteoric or gaseous matter in some portion of space. Now if we were to lump together a thousand stars their individual motions would practically cancel and the resultant super-star would be nearly at rest. Similarly in forming a single star the individual motions, produced by gravitation in the matter of which it is composed, might cancel, so that the star would start from rest.

I find no difficulty in the idea that a star may be born without motion, but it is more difficult to understand how it acquires motion. There is a distinction well known in the theory of attractions: the attraction at a point in a discontinuous medium is regarded as made up of two parts—(1) the corresponding attraction in a smoothed continuous medium, and (2) the part due to the chance distribution of the masses in the immediate neighbourhood of the point considered. Which of these parts is effective in producing a star's velocity? If we followed the analogy of the kinetic theory of gases we should assign the motions to the second cause. But in this connection we have to consider one very important observational fact. In the Taurus cluster, and again in the Ursa Major stream, stars which are well advanced in evolution have evidently preserved throughout their lifetime precisely equal and parallel motions, notwithstanding that they are moving through space occupied by stars not belonging to their system. Is it possible that there have been exceptional circumstances which have enabled these systems to preserve their common motion whereas other similar systems have been broken up? It is hard to think so. If not, it seems that the existence of these clusters leads to the following law:—

The forces which produce the individual velocities of stars are nearly constant over large volumes of space—i.e., large compared with the distance of a star from its neighbour.

Thus in the case of the Taurus stream all the stars of the system have experienced the same force, and have therefore acquired the same velocity.

This law means that it is the central gravitational attraction of the universe, and not the casual interference of neighbouring stars that is effective in changing a star's velocity. It seems to be in accordance with numerical calculation that a neighbouring star can have very little effect. The sun acts on α Centauri, the nearest star, with a force which would take 400 million years to produce a velocity of 1 km. per second. It is true that a close approach of two stars might occur in which the force would be much greater temporarily; but it must be remembered that the change of velocity during the approach would be partly lost as the stars receded; there would be no net increase of kinetic energy. Some transfer of momentum would, however, take place. The following rough calculation may be of interest: If a small star were proceeding with about average velocity and in such a direction that if undisturbed by the sun's attraction it would have passed it at a distance equal to that of the planet Neptune, the result of the close approach would be to change the star's course only 5°.

On the other hand, a resultant force of all the matter of our system seems adequate to produce the stellar motions, though one would rather expect to find more definite traces of a central force and of distinctly radial motions. Perhaps the mistake is to attribute a centre of gravity to the stellar system, which of course does not act as though it were concentrated at a point. A useful, though very rough, idea of the magnitude of the force which the collective attraction of the stars exerts may be gained from the comparison of light and gravitation; since both vary as the inverse square law, we may assert that roughly speaking the attraction towards any part of the sky is measured by the total light of that part of the sky. The total light of the sky seems to be about that of 2,400 first magnitude stars, and I suppose the total gravitation would bear the same ratio to that of an average first magnitude star. Owing to the central position of the sun the pull is pretty uniform in all directions, and there can be little resultant force, but on an eccentrically placed star it would be very appreciable, considering that it would act in nearly the same direction for an almost unlimited time.

A very interesting suggestion as to stellar velocities has been put forward by Dr. Halm.[24] According to his view the Orion stars have small velocities not because they are young but because they are heavy. He proposes a law of equipartition of energy, so that in a mixture of stars of different types the average value of $m v^2$ would be the same for all types. This is the law which prevails in a mixture of gases containing heavy and light molecules. On the observational side our knowledge of the masses of stars is rather small; but such determinations as have been made appear to support Halm's contention. The Orion stars especially are considerably heavier than the others. Also, if we consider the stars as being all formed about the same epoch, it would be natural to expect that the evolutionary development has proceeded fastest in the least massive stars, so that the order of mass may well be also the order of evolution. But if the argument of the preceding paragraphs is sound, the theoretical causes for the law of equipartition cannot be admitted. It is true that equipartition of energy ultimately results, not only when the individuals considered interact by collisions, as in the case of a gas, but also when any kind of interchange of momentum takes place between the individuals subject to the conservation of energy. The gravitational perturbations of the neighbouring stars might thus in time bring about equipartition of energy. But from what has already been said it appears that these attractions have so far had an insignificant effect on stellar velocities. The time required to produce equipartition would seem to be far too great.

Meanwhile there is yet a third possibility that might be considered. Suppose that Orion stars move slowly, not because they are young, or because they are heavy, but because they are distant. Velocities of stars being mainly attributable to a central force of the universe might be expected to increase from the outside towards the centre. I admit

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[24] Halm, *loc. cit.*

that the difference of velocity of the different types seems too large to account for in such a way, and it is very likely that the suggestion will at once break down when tested; still it is at present an alternative to the hypothesis that a star's velocity increases with its age.

There is a certain analogy between the system of stars that we have been considering and the spiral nebulæ, which are very numerous in the sky. The view which is, I suppose, a century old has recently been revived by Sir David Gill and others, that these nebulæ are great stellar systems like our own. Although it is highly speculative, the idea may help us to a possible conception of our own system. We have the bun-shaped centre consisting of uniformly distributed stars. Around this and in the same plane are coiled spirals, which correspond to the star clouds of the Milky Way. Matter is clearly flowing in or flowing out along the two arms of the spiral—the nebulæ are always double spirals. Thus at two opposite ends of a certain diameter of the bun-shaped mass we have opposite currents of matter, and presumably near the centre there must be two currents in exactly opposite directions—in other words, two star-streams. The crucial test of such a theory is whether these spiral nebulæ are sufficiently remote. I understand that evidence has been adduced recently to show that the light of these nebulæ suffers enormous selective absorption of the more refrangible rays, which has been taken to indicate an enormous distance, placing them far outside our own system. This will doubtless be investigated more completely. If confirmed, this hypothesis opens up to our imagination a truly magnificent vista of system beyond system—of universe beyond universe—in which the great stellar system of hundreds of millions of stars that has formed the main theme of this paper would be an insignificant unit.

The Present Position of Electric Steel Melting.

Report by Professor ANDREW MCWILLIAM, *A.R.S.M.*, *M.Met.*

[Ordered by the General Committee to be printed *in extenso.*]

THE melting of steel by means of electricity has passed the merely experimental stage and become one of the commercial processes by means of which steel is manufactured for the market. It is not correct to say that it has emerged from the experimental stage, as not only this process of steel-making but most other processes are being continually experimented with and the results compared with one another by up-to-date and vigorous firms, not only for the new conditions that are always arising but also for old and well-tried conditions.

A new demand arises or repeat orders come in, and the manufacturer must ask himself what kind of steel will best suit the purpose at the present time. Will Bessemer or Open-hearth steel be most suitable to satisfy the demand, price, quality, and all other matters considered and must it be acid steel or will basic do, or is it necessary or desirable to use crucible steel or perhaps this new electric steel, to maintain or increase his profit or his reputation for certain goods? These are problems of daily occurrence, and although the difficulties of the manufacture of electric steel by various processes have been fairly well overcome, so far as making it to specification of chemical composition and mechanical tests is concerned, it is in connection with such questions as are indicated in the previous sentence that it is still in the earlier experimental stage. All other processes, however, are more or less under such trials until they become extinct. The point need not be laboured, for many examples will come to the mind at once, such as the comparative merits for various purposes of Swedish-Lancashire and Walloon iron; of mild steel and wrought iron; of acid and basic steel, and so on. The general impression gathered from much conversation with users is that the arc furnace product from slightly impure materials, purified to Swedish standard, just about takes its place by Swedish Open-hearth and Bessemer steels and that the induction furnace product skilfully made from pure materials equals anything but the very highest qualities of crucible steels. These are very general statements but they represent the writer's present more or less intuitive opinions, and only time can determine whether they are correct, for the fact that steels are of certain chemical compositions and give certain mechanical tests is not a final judgment, but the quality and length of service given in actual use. The special feature of the Héroult and Röchling-Rodenhauser types is that with an oxidising purification phosphorus can be eliminated to almost any extent that will pay, and after removing the slag, and forming another, by a reducing purification sulphur can similarly be removed.

The Kjellin induction furnace acts as a melter of materials much after the manner of the crucible, and has one advantage over the crucible in that there is no absorption of sulphur during melting. Recent experiments with covering slags specially calculated by the writer to

give a minimum of change in composition during melting show, according to a student's preliminary analysis, compositions in the ingots practically equal to those by calculation from the constituents, a result better than expected but still requiring thorough checking. The results at least serve as a text for one fact that must never be forgotten. The electric furnace of whatever design will not make good steel automatically. The same metallurgical skill required by the older processes must be expended on the proper killing and finishing of the steel, by whatever type of electric furnace it is being melted, and the fact that in electric as in other furnaces bad steel may be made from good materials increases the difficulties of finding the exact place of any steel in the world's work. Several cases where the electric steel has been found unsuitable, especially in the earlier days, have been investigated, and it has been found that the steel has been wrongly made. In other cases no such explanation could be given. Recently I had a long talk with a man using large quantities of electric steel; he could get great purity but no better mechanical tests, yet he found the electric steel gave a better life than his former steel and so he used it. Here again another difficulty comes in as represented by the fact that I did not think his ordinary steel was specially well made.

One point of importance is that this production of electric steel has introduced a new competitor into the field by giving great impetus to the use of what is sometimes called white coal—namely, the great waterfalls, mostly far removed from coal—and much energy is now being used that formerly ran to waste, whilst the successful application of electric power to the production of charcoal pig-iron allows of a much-reduced consumption of charcoal. The rapidly increasing price of charcoal in Sweden, owing among other causes to so much of the wood being used for making wood pulp for paper-making, is quite a serious situation which this application of electric power may help to relieve.

The whole subject of electric iron-smelting and electric steel-melting is attracting much attention. Several books have been published on electric furnaces, and during 1909 and 1910 many interesting articles on the subject have appeared in the technical journals, and many papers have been read before the Iron and Steel Institute. At the Autumn meeting of 1909, Mr. C. A. Ljungberg gave a paper on 'Production of Iron and Steel by Electric Smelting Processes.' He mentioned the Kjellin electric induction furnace at Gysinge, with which the writer had the pleasure of making with Mr. E. C. Ibbotson a full week's trial, as being still in work, making tool steel, special steels, self-hardening and high-speed steels, and others such as nickel and chromium steels. The paper dealt more in detail, however, with the successful experiments on smelting pig-iron at Domnarfvet by electrical means and the resulting saving in the proportion of charcoal used.

It will be only necessary merely to touch upon the various principles used in the construction of electric furnaces as these are found in text-books and in the proceedings of the Iron and Steel Institute. Having obtained an electric current, its energy may be converted into heat by putting a suitable resistance in its path, and the heat may be concentrated at any part of the circuit by making the resistance of other parts

small in comparison. If the resistance be a solid or a liquid, then it is called resistance-heating; if a gas, arc-heating. If the liquid through which the current passes is decomposed by the current so that one kind of matter goes to one pole and another kind to the other pole the liquid is called an electrolyte.

Varieties of Electric Furnaces.

The Stassano furnace is an independent arc furnace. Three carbon electrodes are used, between which arcs play, and the heat from the arc is merely used for heating the charge, partly by direct radiation and partly by reflection from the dome of the furnace.

The Héroult steel-melting furnace is a direct arc type, in which the charge forms one pole of the arc. Two vertical carbon electrodes come through the roof of the furnace and two arcs play, one between each electrode and the molten metal or slag beneath it, the current passing from one electrode through the metal or slag and up through the other electrode.

The Girod furnace, like the Héroult, is a direct arc furnace, but one or more electrodes of like polarity are maintained above the bath, and soft steel pieces embedded in the hearth of the furnace are in direct contact with the molten metal for the negative electrode. These lower pole-pieces are water-cooled. Large quantities of ferro-silicon, ferro-chrome, &c., as well as of ordinary carbon and special steels are made in this furnace.

The Keller steel furnace is a direct arc furnace, very much like the Héroult, only instead of two electrodes coming down into one cavity they come into separate cavities which are joined by the molten material of the bath.

The Grönwall is of the arc type and the current enters by two electrodes through the roof, and when once the bath is heated so that the lining becomes a conductor the current from both electrodes passes though the lining to a graphite block underneath, and hence to a common wire.

The Nathusius, like the Grönwall, is a combined arc and resistance furnace. It contains three vertical carbon electrodes, arranged at the apices of an equilateral triangle, and three steel electrodes similarly arranged in the bottom of the furnace but covered by refractory material. Three-phase current is used and it is claimed that the current flows from one top electrode to the others, from one bottom electrode to the others, and from each top electrode to each bottom electrode.

Kjellin Induction Furnace.—In this furnace, an example of which is in the Metallurgical Laboratory of the University of Sheffield and was shown working to the members of the British Association, the metal charge is placed in an annular hearth, almost like a steel-melting crucible in section, but in the form of a ring. The primary coil of twenty-four turns is placed in the centre round a core of laminated iron. The bath or ring of metal acts as a secondary circuit of a single turn and the heat is thus produced in the charge itself without contact with electrodes. In the Frick furnace the primary coil is above the crucible, and in the Colby round the outside of the crucible.

The Röchling-Rodenhauser furnace is based on the Kjellin principle

but has an important addition. In its simplest form for single-phase current there are two grooves or heating channels corresponding to the annular crucible of the Kjellin, but these join to a central open-hearth, the whole hearth forming a kind of figure 8. In the central open-hearth all the distinctly metallurgical operations take place, so that this form can be used for refining work for which the Kjellin is not very suitable. Not only so, but a distinct secondary winding is provided in which a secondary current is induced, and these windings are joined to steel terminal-plates which are embedded in the refractory material of the furnace at the ends of the central hearth. At high temperatures the refractory material becomes a conductor of electricity and thus the currents induced pass through the bath in the central hearth, heating it still further.

There are many others, some only on paper, but these are the principal varieties that have been tried with any considerable degree of success. The loss in melting is an important point, and I am informed that this amounts to about 1½ per cent. in the Kjellin, about 4 to 5 in the Röchling-Rodenhauser, and 7 to 8 per cent. in arc furnaces.

In considering the present position of the electric steel-melting industry regard must be had to the numbers and capacities of the various types of furnaces in work, not in work, and being built, although a complete survey should also take account of the nature and quality of the materials being made, for a furnace making a ton of high-speed steel should obviously be credited with more importance in the commercial world than one making a ton of steel for rails. The progress in numbers and capacities and in output should also be considered. So far as one could ascertain, about June 1910 there were about 118 furnaces of all types, of which 70 were in use, 10 not working, and 38 being built. There were 77 of the arc furnaces recorded, of which 29 were credited as Héroult, 17 Girod, 13 Stassano, 6 Keller, and 9 others; besides one furnace at Domnarfvet, Sweden, for the production of 2,500 tons of pig iron per annum, with one in Norway and one at Trollhättan, Sweden, both in course of construction and each designed to produce about 7,500 tons of pig iron annually. Of the Héroult furnaces the total capacity per charge of those working was about 80 tons and of those in course of construction about 50 tons. The Girod furnaces, the great competitors of the Héroult, were recorded at about 38 tons in work and 26 tons being built. Similarly the figures for the Keller were 13 tons and 5 tons, and for the others 20 tons and 13 tons respectively.

Of the induction furnaces the Kjellin furnaces erected totalled fourteen with 35 tons capacity, the Röchling-Rodenhauser fifteen, with 30 tons in work, 1 ton not in work, and 17 tons capacity being built, all others about 18 tons in work. That gave a total capacity of about 250 tons for the arc furnaces and 100 tons for the induction, or a grand total of 350 tons per charge for all electric steel-melting furnaces. Pressure of other work has prevented me getting the latest figures from all the firms making electric furnaces, but I have obtained these from the two most important firms, viz., the Héroult and the Kjellin and Röchling-Rodenhauser, and in this connection would record my best thanks to Mr. Donald F. Campbell, B.Sc., A.R.S.M., and Mr. E. C. Ibbotson respectively for their kind help and trouble in getting me this

LIST OF KJELLIN AND ROCHLING-RODENHAUSER FURNACES, NOW IN OPERATION OR IN ERECTION.

Type	No.	Country	Firm	In Operation	Not in Operation	In Erection	Kind of Current	Kw.	Notes
				Charge Kg.					
Kjellin	1	GERMANY.	Fr. Krupp, A.-G., Essen a.R.	8,500	...		Single phase	750	
	2		Oberschlesische Eisen ind. A.-G., Gleiwitz	1,500	...	...	Single phase	180	
Röchling-Rodenhauser	3		Röchling'sche Eisen- & Stahlwerke Volklingen	7,000			Single phase	750	
	4			2,000	...		Three phase	275	
	5			...	...	2,000	" "	275	
	6			...		2,000	" "	275	
	7		Pilgar & Neidhardt, Frankfurt a.M.	..	...	2,000	Single phase	275	
	8		Bergische Stahlindustrie Remscheid	5,000	...	...	Single phase	500	
Röchling-Rodenhauser	9	LUXEMBURG.	Le Gallais, Metz & Co., Dommeldingen	3,500	...	...	Single phase	380	
	10			3,500	...		" "	380	
	11			700	...		" "	100	
	12			1,500	..		Three phase	275	
	13			3,500	...		Single phase	380	
Kjellin	14	AUSTRIA.	Poldihütte, Kladno	4,000	..	..	Single phase	440	
	15		J. Braun's Söhne, Vocklabruck	400	...	...	Single phase	65	In operation when water available.
Röchling-Rodenhauser	16	FRANCE.	Aciéries de la Marine et d'Homecourt, St. Chamond	...	...	3,000	Three phase	350	
Kjellin	17	GREAT BRITAIN.	Vickers, Sons & Maxim, Sheffield	...	1,500		Single phase	230	Not in operation at present moment.
	18			...	...	180	"	100	
	19		W. Jessop & Sons, Sheffield	...	...	1,800	Single phase	250	
	20		The University of Sheffield	100	...	...	Single phase	60	Experimenting furnace.
Röchling-Rodenhauser	21	BELGIUM.	Aciéries Liégeoises, Bressoux-les-Liége	...	1,000	...	Three phase	200	Firm in liquidation.
Kjellin	22	ITALY.	Alti Forni Gregorini, Lovere	...	...	1,500	Single phase	330	
Kjellin	23	SPAIN.	Vidua de Urigoitia é Hija, Araya	1,500	...	...	Single phase	215	In intermittent operation.
Kjellin	24	SWEDEN.	Domnarfvets Jernverk (Gysinge)	1,500	...	...	Single phase	175	
	25		Sybry Searls Ltd., Trollhättan	2,000	...	...	Single phase	300	In operation when water available.
Röchling-Rodenhauser	26	RUSSIA.	Kronwerke Slatoust	...	...	1,000	Three phase	175	
Kjellin	27	U. S. A.	American Electric Furnace Co., Niagara Falls	750	...	...	Single phase	150	
Colby	28			100	...	...	"	60	
Kjellin	29		General Electric Co., Schenectady	80	...	...	Single phase	50	
Röchling-Rodenhauser	30	MEXICO.	Ricardo Honey, Mexico	...	...	2,500	Three phase	300	

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Besides: 1 Furnace at the Berndorfer Metallwarenfabrik, A. Krupp, Berndorf, for treatment of nickel and nickel alloys.

Electric furnaces are being employed in the following cases:—

(1) To replace crucibles. The gain is then one of cost of production.

(2) For foundries. Electric furnaces are being used in many foundries. At Georg Fischer's and Schaffhausen they are the only furnaces employed, and Lake and Elliott of Braintree are now making most of their steel electrically.

(3) To replace Swedish Bessemer steel, and for steel of axle and tyre quality.

(4) For weldless tubes. The Mannesmann Company have Héroult furnaces in Germany and Italy.

(5) In combination with Talbot furnaces. Owing to the fact that the heat need not be sufficiently great for teeming on transference to the electric furnace, the output of the Talbot and the life of the lining and roof are said to be largely increased. This will be the procedure at Skinningrove for making rails.

(6) For melting turnings, especially high-speed turnings. These make excellent scrap for the electric furnace. Nickel scrap can be melted without any loss of nickel.

There are two aspects of the present position of a comparatively new industry. One is the progress made during the year, and an endeavour has been made to present that point of view. Another aspect is the actual state of the industry at present and that can best be judged by the accompanying two tables representing the furnaces, capacities, and kind of work done by all the furnaces under the care of the two principal firms already named. A very interesting item in the induction furnace list is the entry representing the fact that the Kjellin furnace has been adopted for melting the metal for the manufacture of those delightful though expensive culinary vessels of pure nickel so much appreciated now.

List of Héroult Furnaces in Construction or Operation.

Country	Firm	Size of Furnace	Method of Melting
		Tons	
England	Edgar Allen & Co., Ltd., Sheffield.	2½	Tilting basic open-hearth.
	Skinningrove Iron Co., Yorkshire	15	Talbot.
	Vickers, Ltd., Sheffield.	3	Melting scrap in electric furnace.
	Thos. Firth & Sons, Ltd., Sheffield.	2½	,, ,,
	Lake & Elliott, Braintree.	2½	,, ,,
Austria	Kaernthner Eisen & Stahl Werke	5	,, ,,
	Gebr. Böhler & Cie. A.G. Kapfenberg	2½ 4	,, ,, ,, ,,
	Brüder Lapp, Rottenmann, Works, Steiermark.	6	,, ,,
	Danner & Co., Judenberg.	2	,, ,,
Belgium	Société des Usines Métallurgiques du Hainaut, Coultret.	5	Basic open-hearth.
	Société Anonyme Ougrée-Marihayé, Near Liège.	5	,, ,,

List of Héroult Furnaces in Construction or Operation—continued.

Country	Firm	Size of Furnace	Method of Melting
		Tons	
France	Société Electro-Métallurgique Française, La Praz, Savoie.	2½	Melting scrap in electric furnace.
	Aciéries du Saut du Tarn, St. Juèry.	5	,, ,,
	Usine Métallurgique de la Basse Loire, Trignac.	5	Basic open-hearth.
Germany	Works of August Thyssen :—		
	Deutscher Kaiser Stahlwerke, Bruckhausen.	7	,, ,,
	Deutscher Kaiser Stahlwerke, Mülheim.	6	,, ,,
	Deutscher Kaiser Stahlwerke, Bruckhausen.	25	,, ,,
	Stahlwerke Richard Lindenberg, Remscheid-Hasten.	2 3	Tilting basic open-hearth.
	Bismarckhütte, Upper Silesia.	1 3	Melting scrap in electric furnace.
	Mannesmann Röhren Werke, Saarbrücken, Burbach.	3	Open-hearth.
	Rombacher Hüttenwerke, Rombach.	22 3	,, ,,
	Deutsch Luxemburgische, Dortmund.	7 7	,, ,,
Italy	Società Tubi Mannesmann, Dalmine	6 6	Melting scrap in electric furnace.
Russia	Imperial Steel Works, Obuchow, St. Petersburg.	3½	Open-hearth.
	Aktiengesellschaft der Hütten- und mechanischen Werke, Ssormovo.	3	,,
	Société Générale des Hts. Fourneaux & Aciéries en Russie, Makejawka.	3	,,
Sweden	Aktiebolaget Héroults Elektriska Stal, Kortfors.	6	Melting scrap in electric furnace.
Switzerland	Georg Fischer, Schaffhausen.	1½	,, ,,
Canada	Electro Metals, Welland.	½ 5	,, ,, ,, ,,
United States	United States Steel Corporation, S. Chicago.	15	Bessemer.
	United States Steel Corporation, Worcester.	15	Basic open-hearth.
	Firth-Stirling Co., Syracuse, New York.	2½ 5	Melting scrap in electric furnace.
	Halcomb Steel Co., Syracuse, New York.	5	Tilting basic open-hearth.
	Crucible Steel Co. of America, Pittsburg, Pa.	5	Basic open-hearth.
Mexico	Cie. Mexicano Acero & Productos Chemicos.	4	Melting scrap in electric furnace.
	43 Furnaces	242½	

The Sensitiveness of Indicators. *By* H. T. TIZARD.

[Ordered by the General Committee to be printed *in extenso.*]

BEFORE we could distinguish so accurately as we can at present between degrees of acidity, an indicator was regarded as a substance with the remarkable property of suddenly changing its colour as the solution in which it was contained became either 'acid' or 'alkaline,' pure water being taken as the standard of neutrality. It was Ostwald who, as is well known, brought forward a simple and convincing ionic theory of indicators which was sufficient to explain all the facts known at that time, and which even now it has only been found necessary to alter to a relatively unimportant extent. According to him, the change of colour was brought about directly by a change in the ionisation of the indicator; an indicator was to be looked upon as a weak acid or base, the ions of which had a different colour in solution from that of the undissociated molecule. Modern experience teaches us that simple ionisation of this kind is not as a rule accompanied by any deep-seated change in colour; the colours of copper sulphate, and potassium permanganate, for example, appear absolutely unaltered on dilution from moderately strong to very dilute solutions, although these salts are completely ionised in the latter, and largely in the undissociated state in the former. Sometimes we observe in such solutions a slight alteration in the *depth* of colour on dilution, but it is now generally admitted that a considerable change in the absorption is only brought about by a considerable change in the constitution of the molecule. We therefore regard indicators not as *true*, but as pseudo-acids or bases, and assume that the undissociated molecule is really a mixture of one or more tautomeric forms in equilibrium, only one of which ionises to any considerable extent. Thus on the old theory, an indicator was an acid, say XOH, which dissociated into ions XO' and H°, XOH and XO' being differently coloured in solution. On the new theory an indicator, in the undissociated form, is a mixture of two (or more) forms, HXO and XOH, in equilibrium; and under suitable conditions the form XOH ionises, giving rise to the ions XO' and H°. The equilibrium equation may then be written in the form :—

$$[HXO \rightleftarrows XOH] \rightleftarrows XO' + H^\circ.$$

Of these different molecular species, XOH and XO' must be similarly coloured, or, to speak more strictly, must absorb light to a similar extent in solution: HXO, being a differently constituted molecule, may exhibit an entirely different colour in solution. Thus HXO may be deep red, XOH and XO' pale yellow, in equivalent solutions. If the equilibrium between HXO and XOH leans very much to the side of the former—if, for example, there are always 1,000 molecules of HXO to every molecule of XOH—then the colour of the solution which contains practically no XO' ions will be entirely due to HXO. When ionisation takes place, the ions XO' and H° are formed from XOH, some of the latter disappears, and hence the equilibrium $HXO \rightleftarrows XOH$ readjusts itself. Finally we may

have a large amount of XO′ ions in the solution, and a very small amount of HXO and XOH. The colour of such a solution will be entirely due to the ions. Further, the law of mass action requires that the proportion of HXO to XOH molecules in the solution must always be constant, so that from a physico-chemical standpoint it is quite legitimate to speak in this case of the undissociated molecule being red in solution, provided we always understand by the 'undissociated molecule' the equilibrium mixture of tautomeric forms. For simplicity's sake then, we keep to Ostwald's original theory in discussing the conditions under which the colour change of an indicator takes place, always remembering to allow due weight to the modern conception of the 'pseudo-acid' when necessity for this arises. One condition, however, must be noticed. It is essential that the actual chemical change of an indicator from one coloured form to another should be rapid: now, as we have seen, the ionisation of an indicator is accompanied by a simultaneous tautomeric change, and it is on this that the change in colour really depends. The formation and combination of ions *is* instantaneous; a tautomeric reaction not necessarily so. Hence we arrive at a necessary condition for a good indicator: that the tautomeric change from the pseudo to the true acid form should be so rapid as to be practically instantaneous. Cyanine is an example of a bad indicator from this point of view, since its colour change takes an appreciable time.

The question of the *chemical constitution* of the different possible forms of an indicator is of great interest, especially when the indicator is 'amphoteric,' that is to say, has both basic and acidic groupings in the molecule, as, for example, methyl orange. But this question is impossible to treat from a general point of view; its discussion is best confined to individual cases. For this reason I shall not go into it at present, but merely mention it in passing as a subject whose intrinsic interest and importance make it especially valuable for discussion in a meeting like the present. In particular there is the disputed question whether the colour change of an indicator such as methyl orange is primarily due to its basic or acidic functions, a question upon which opinion appears to be sharply divided.

In volumetric analysis we use indicators, broadly speaking, to discover when exactly equivalent quantities of solutions of bases and acids have been added to each other. Experience has shown, however, that not only do different indicators often give widely different results in one particular experiment, but also that an indicator which appears to give satisfactory results in one case will not do so in another. It becomes therefore essential to discover precisely under what conditions the colour change of an indicator takes place, and to define exactly the steps we must take to select an indicator which will give the best results in any particular volumetric operation. Since, as we have already seen, the change in colour is produced, directly or indirectly, by a change in ionisation, this problem reduces to one of defining the conditions under which an indicator dissociates.

Now let us consider, for simplicity's sake, an indicator [1] which is a

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[1] The following method of treatment applies equally to basic indicators. Some indicators have more than one colour change, and hence cannot be treated in so simple a manner, but these are not in common use. Methyl red, an exception to the last statement, has two distinct colour changes, but one of these is negligible in ordinary circumstances, although it becomes of importance when this indicator is used for the colorimetric determination of hydrion concentrations.

weak acid, and let its degree of ionisation in solution be represented by α. Then the application of Ostwald's dilution law gives :—

$K_a \times$ concentration undissociated molecules = concentration dissociated molecules $\times$ concentration H°.

$$\text{or} \quad K_a \times \frac{1-\alpha}{\alpha} = \text{concentration H}^\circ ;$$

where K_a is the dissociation constant of the indicator.

The degree of ionisation of an indicator, and therefore its colour, depends only on the constant K_a, and the concentration of hydrogen ions (hydrions) in the solution.

If $\alpha = \frac{1}{2}$

$$K_a = \text{concentration H}^\circ \,.\ (C_H).$$

Hence when the concentration of hydrions in the solution is numerically equal to the dissociation constant of the indicator, the latter is half in the form of unionised molecules, and half in the form of ions, and exhibits a colour exactly midway between the two extreme colours of its unionised and ionised forms.

If $C_H = 10\ K_a$, $\alpha = 9$ per cent. ; that is to say, the indicator is practically entirely in the undissociated form, and the colour of a solution containing this, or a greater, concentration of hydrogen ions will be practically that due to the undissociated form of the indicator. On the other hand, if $C_H = \frac{1}{10}\ K_a$, $\alpha = 91$ per cent., and the colour of such a solution, and of any still more weakly acid, will be that due to the ions of the indicator.

This is an important conclusion ; if we know the strength of the indicator, we can say at once within what concentrations of hydrions its colour change will take place.

These conclusions may be demonstrated in the following way. A number of aqueous solutions are prepared, so that the concentrations of hydrions in them are respectively 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} (neutral point at 25°), 10^{-8}, 10^{-9}, 10^{-10}, 10^{-11}.[2] The range of sensitiveness of an indicator can then be tested by placing small equal quantities of it in turn in the different solutions. Thus methyl orange is found to be completely red in the 10^{-3} solution, orange-coloured at 10^{-4}, and yellow at 10^{-5}. We conclude therefore that the dissociation constant of methyl orange must be somewhere in the neighbourhood of 10^{-4}, and that it can be used to indicate hydrion concentrations varying from 10^{-3} to 10^{-5}. Methyl red is completely red at 10^{-4}, light red at 10^{-5}, and yellow at 10^{-6}. Hence its dissociation constant is about 10^{-5}, and its range of sensitiveness is approximately from 10^{-4} to 10^{-6}. Phenolphthalein is colourless at 10^{-7}, faintly coloured at 10^{-8}, and deeply coloured at 10^{-9}, and so on.[3]

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[2] Formulæ for the preparation of these solutions are given by Noyes, *Journ. Amer. Chem. Soc.*, 1910, p. 815.

[3] Professor Walker proposes the use of the terms 'relative acidity' and 'relative basicity,' in order to avoid the mathematical expressions 10^{-3} &c. Thus since the concentration of hydrions in pure water at 25° is 10^{-7}, a solution with a concentration of 10^{-6} would have a 'relative acidity' of 10 ; and one with a concentration of 10^{-8}, a 'relative basicity' of 10. This nomenclature should probably be found convenient by analysts.

It is evident that if we wish to define with greater exactness the ranges of sensitiveness of indicators in this way we must measure as accurately as possible their dissociation constants. This, however, is by no means an easy task; an indicator is generally both too weak and too insoluble an electrolyte for us to be able to determine its dissociation constant by the ordinary conductivity method. The only accurate method appears to be a quantitative measurement of the depth of colour of the indicator in solutions of different, accurately known, concentrations of hydrions. This is only convenient when the indicator is only coloured in one form or has two coloured forms which practically do not differ in tint, but only in depth of colour.[4] Approximate determinations made by means of the solutions already referred to are sufficient for most ordinary work, and it would be of the greatest assistance if in future every discoverer of a new indicator would test his product in this manner.

Since the concentration of hydrogen ions in pure water is 10^{-7} at 25°, it follows that the exact neutral point is only indicated by an indicator with a dissociation constant of about 10^{-7} (litmus). It does not follow that this is the most useful indicator, in fact the contrary is true. Speaking generally, however, we may say that the most sensitive indicators are those which have dissociation constants not widely different from 10^{-7}; for evidently the change from 10^{-3} to 10^{-5} (methyl orange), that is from one-thousandth to one-hundred-thousandth normal, is more considerable than the change from one-millionth to one-hundred-millionth normal. An indicator must therefore be a weak acid or base, as Ostwald said. But it must not be too weak; an indicator with a dissociation constant of 10^{-11}, for example, changes over between concentrations of hydrogen ions of 10^{-10} and 10^{-12}, that is to say between concentrations of hydroxyl ions of 10^{-4} and 10^{-2} (since $C_H \times C_{OH} = 10^{-14}$ at 25°). Such a change is only brought about by addition of a considerable amount of alkali.[5]

It is now possible to apply these conclusions to the actual process of titration. If an alkaline solution be gradually added to an acid solution, the concentration of hydrogen ions in the latter becomes smaller and smaller until a point is reached when the indicator present begins to dissociate appreciably. This point may or may not be the point when exactly equivalent quantities of base and acid are present together; that depends obviously upon the indicator used. Now we can either stop the titration directly we observe a distinct change in colour, or when further slight addition of alkali has no more appreciable effect. In practice it has been found most convenient to take as our end-point the *last* part of the colour change when we titrate from a dark to a light colour, and the *first* part of the colour change when we titrate in the reverse direction; and

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[4] See *Journ. Chem. Soc.*, 1910, p. 2477.

[5] The range of sensitiveness of an indicator probably alters considerably with the temperature. The 'apparent' dissociation constants of all pseudo-acids and bases have been found to have high temperature coefficients, and indicators should form no exception to this rule. If a 200th normal solution of acetic acid ($C_H = 3 \times 10^{-4}$) containing methyl orange be warmed from 0° to 25°, the colour of the solution becomes distinctly paler, although the dissociation constant of acetic acid alters very little with the temperature, and in any case C_H does not become smaller. The phenomenon is best explained by an increase in the dissociation constant of methyl orange. It follows that when indicators are used for the colorimetric determination of hydrion concentrations, care should be taken to keep the temperature constant—a precaution which has not been thought necessary up to the present.

it is evident that, other things being equal, those indicators will give the sharpest and most satisfactory end-point which exhibit the greatest difference in depth of colour or tint between their two forms, because it is then an easy matter to detect a very small change in ionisation. Does the end-point depend upon the amount of indicator present? In the case of two-coloured indicators, such as methyl orange and methyl red, it does not, for we always titrate to a certain *fractional* change of the indicator. With mono-coloured indicators, such as phenolphthalein, it is different. In this case we go on adding alkali until there is a perceptible colour in the solution—that is to say, until there is a certain *amount* of coloured substance in the solution. If there is a large quantity of indicator present, this amount may be a very small fraction of it; if a small quantity, this amount may be a large fraction, and a glance at the equation

$$\sqrt{K_a \times \frac{1-a}{a}} = \text{concentration } H^\circ$$

will show that the smaller a is, the higher is the concentration of hydrogen ions indicated. A limit is, however, put on this by the insolubility of the indicator. In the particular case of phenolphthalein, the more indicator we use the more sensitive it is to small concentrations of hydrions, and the nearer is its 'end-point' to 10^{-7}, the theoretical neutral point. Owing to its insolubility, however, it is doubtful whether it can be used to indicate concentrations of hydrogen ions higher than $10^{-7 \cdot 5}$.

This influence of the amount of indicator present in the solution has not been sufficiently recognised, and may partly account for the differences in the values for the end-point of phenolphthalein given by different observers.

It may be remarked that it is possible for the amount of indicator present to affect the titration in another way. It has already been said that if a two-coloured indicator is used, the titration is continued until a certain fraction of the indicator, say about 95 per cent., is changed over into the form of ions. Now this change, or neutralisation, of the indicator does actually require a certain definite amount of alkali for its completion, and the more indicator is present the more alkali will be needed. Most indicators of this class are, however, used in such dilute solution that this effect is negligible; and it is further important to notice that even if the concentration of the indicator is moderately high, the accuracy of the titration will not be affected if the indicator is originally put into the solution in the same form as it will have at the end of the titration. From this point of view, such indicators as methyl orange, methyl red, nitrophenol, must be used in the form of their sodium or potassium salts.

Bearing all these facts in mind it is possible to draw up a table showing the 'end-points' of various indicators when used in the ordinary manner in titration. Thus we have already seen that the colour change of methyl red is only complete when the concentration of hydrogen ions is something less than 10^{-6}; and the end-point observed when methyl red is used as an indicator in the ordinary manner lies somewhere between $10^{-5 \cdot 7}$ and $10^{-6 \cdot 4}$, the variation being relatively unimportant, and due to the inability of the eye to detect small changes in colour without a special apparatus. The following table gives the values of the end-points of the more common indicators; the actual numbers are probably not extremely accurate in

some cases, but our knowledge is at present too imperfect to allow of their being defined with greater precision :—

Methyl orange	$10^{-4\cdot5}$ to $10^{-5\cdot5}$
Methyl red	$10^{-5\cdot7}$ to $10^{-6\cdot1}$
Litmus	$10^{-6\cdot5}$ to $10^{-7\cdot5}$
Phenolphthalein	$10^{-8\cdot2}$ to 10^{-9}
Thymolphthalein	$10^{-10\cdot5}$ to $10^{-11\cdot5}$

Having arrived at these numbers, all that remains is to consider how the concentration of hydrogen ions changes in a solution when we titrate acids and bases of various strengths. When we know this, we can not only decide upon the best indicator to use, but also estimate the probable error in using it, and the absolutely certain error in using any different one. If the acid and base used are both 'strong' electrolytes, for example HCl and NaOH, then when equivalent quantities are present in solution we have an exactly neutral solution of an unhydrolysed salt (NaCl), and the concentration of hydrions will be exactly the same as in pure water, namely 10^{-7} at 25°. Also, a very slight excess of acid and base makes an enormous difference in the concentration of hydrions in the solution. This can be seen most clearly by the accompanying curve, which represents the change in H° ion concentration when the titration of 50 c.c. of $^{N}/100$ HCl by $^{N}/100$ NaOH is almost complete. As ordinates are plotted the number of c.c. of base added; the abscissæ represent the concentration of H° ions. When 49·95 c.c of base are added the concentration of hydrions is 10^{-6}; when 50·05 are present, C_H is 10^{-8}; thus two drops of the alkali, or two parts in 1,000 present, diminish C_H to 100th part. Along the curve are written in the various indicators at points which correspond to the 'end-points' they indicate. It will be seen that methyl red, litmus, phenolphthalein, coming as they do on the flat, or most sensitive part of the curve, all give sharp end-points, by which we mean that a small trace of the

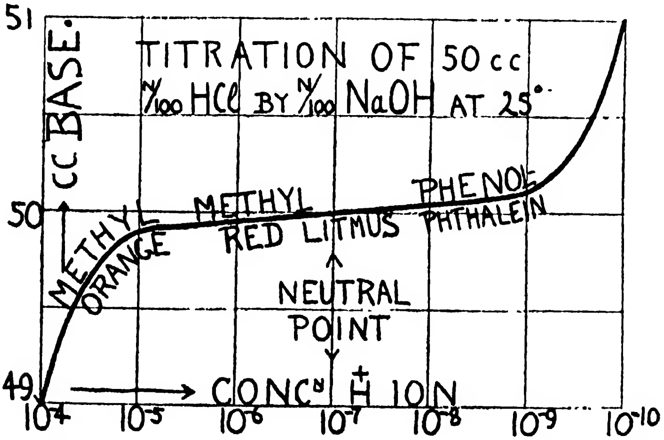

FIG. 1.

titrating solution is enough to make a sharp change in the colour. For methyl red about a drop of alkali is enough to decide its end-point; but the result so obtained (49·95 c.c.) may differ by about 1 part in 1,000 from the true value. Phenolphthalein gives an equally sharp end-point, the error of which is a little over 1 part in 1,000 in the other direction. We could therefore titrate with both in the solution, and take as the most correct result the mean of the two values obtained. For most purposes, however, an accuracy of 1 part in 1,000 is ample. Methyl orange, however, comes on the steep part of the curve, and its colour changes comparatively slowly. Also the final result, which will be about 49·8 c.c., is considerably less accurate than those given by the other indicators used. Litmus should give the exact point; many workers find it, however, an inconvenient indicator to use; perhaps if its constitution could be determined, and a pure product prepared, it would again come into extensive use.

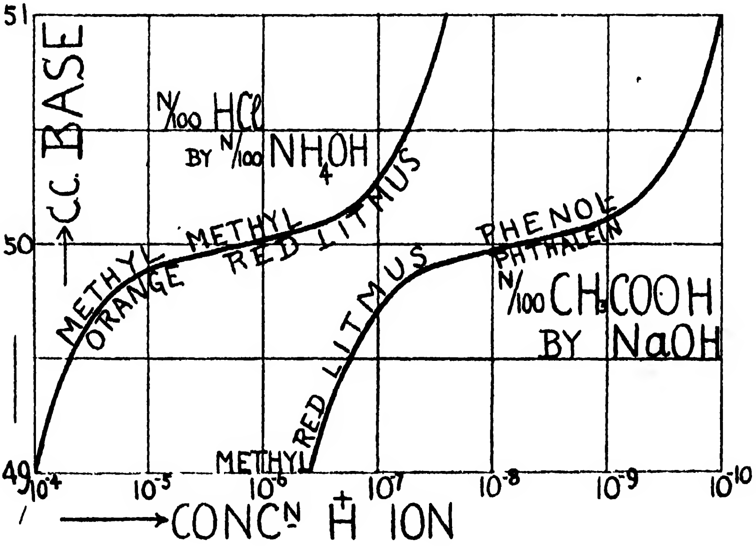

Fig. 2.

Still more striking is the difference between the results obtained by using various indicators when one of the titrating liquids is a weak electrolyte. In this case, as is well known, the concentration of H° ions in the solution when exact equivalents of acid and base are present is not the same as in pure water, owing to the hydrolysis of the salt, or, in other words, incomplete combination of the acid and base. Further, excess of acid or base does not alter the concentration of H° ions to a large extent, since it is partly used up in destroying hydrolysis; also, if the weak electrolyte is in excess, the degree of its dissociation, small in any case, is further reduced by the presence of the neutral salt. Even in the titration of ammonia by HCl, and acetic acid by soda, where hydrolysis is as a matter of fact extremely small, and easily destroyed altogether by a slight excess of

either constituent, we find that the flat part of the curve is much narrower and much less flat. Instead of there being a number of indicators which would give accurate results, we find only methyl red in one case, and phenolphthalein in the other. Methyl red gives not only an accurate but a sharp end-point in ammonia titrations; phenolphthalein, instead of also giving an accurate result, gives an extremely inaccurate one, certainly not within 2 or 3 per cent. Methyl orange gives a better result in this case than phenolphthalein, but still not a sharp end-point. These facts have of course been long known, but the curves show well the magnitude of the errors involved—an important factor. In the titration of acetic acid by soda, methyl red gives an inaccurate and extremely bad end-point, phenolphthalein a sharp and accurate one. If the base or acid used is still weaker, it becomes very difficult to find a good indicator, and finally impossible; the flat part of the curve in fact tends to disappear until at last it does so altogether. As an example we can take *aniline*. Here, owing to the great hydrolysis of aniline hydrochloride in solution, the concentration of hydrions at the 'equivalent' point is as high as $10^{-3\cdot5}$, and a large excess of acid or base produces only a slight change in this value. Since such concentrations of H° ions *do* actually affect the colour of methyl orange appreciably, it might be possible to titrate aniline to about one per cent. by using a comparison solution and a colorimeter, but evidently it is quite impossible to find an indicator capable of giving even moderately accurate results without this means.[6]

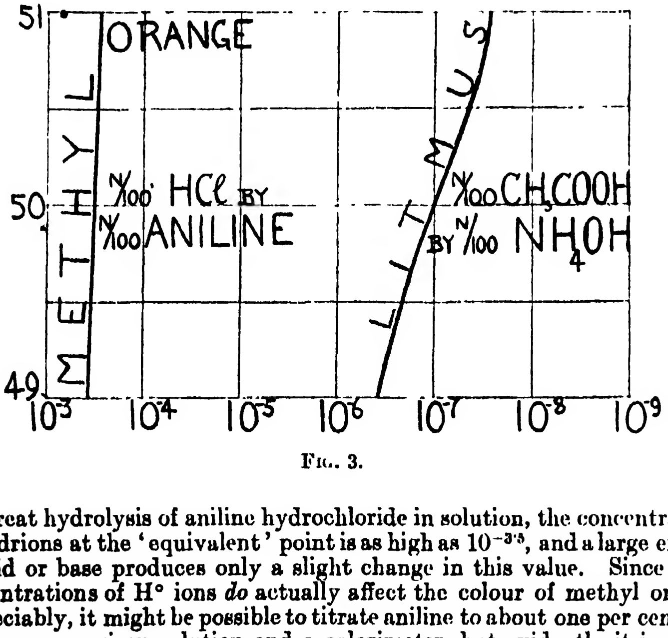

FIG. 3.

A curve showing the titration of ammonia by acetic acid is also given: it will be seen that even though the concentration of hydrions at the

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[6] The concentration of hydrogen ions at the (true) end-point of a titration alters of course with the temperature, being in general about three times as small at 0° as it is at 25°. Reference to the curves given will show that this difference has very little effect on the probable accuracy of the titration, except when the acid or base titrated is extremely weak. It must be remembered that the effect is considerably lessened by a simultaneous decrease in the dissociation constant of the indicator.

'equivalent' point is 10^{-7}, the curve is very nearly a straight line, and litmus is the only indicator that might possibly give moderately accurate results. But as it is never necessary to titrate a weak acid by a weak base, it is unnecessary to discuss this and similar cases further.

This method of regarding the problem may of course easily be extended to such examples as the titration of a dibasic acid, or of one acid in presence of another (CO_2), but it is impossible within the limits of this paper to consider these in detail.

The general conclusions to be drawn from the curves are these: firstly, that if we can find an indicator which will give a sharp and satisfactory 'end-point' in any particular volumetric operation, then the end-point so indicated will probably be accurate to within two parts in a thousand; secondly, that if no indicator will give a satisfactory end-point, then the only way to obtain really accurate results is to find an indicator the colour of which is sensibly affected at the concentration of hydrions obtaining in a pure solution of the salt of the strong and weak electrolytes, and then, using a comparison solution of the salt containing the same amount of indicator as the titrating solution, titrate to the same colour. In extreme cases results obtained by judging the colours with the unassisted eye will be too inaccurate, and a form of colorimeter should be used.

Momentum in Evolution.

By Professor ARTHUR DENDY, *D.Sc., F.R.S.*

[Ordered by the General Committee to be printed *in extenso.*]

IT is a fact well known to palæontologists that many widely separated groups of the animal kingdom have, during the course of their evolution, and especially towards the end of that course shown a strongly marked tendency to enormous increase in size.[1] We see this in the extinct eurypterids, giants amongst the arthropoda, in the huge labyrinthodont amphibians, in many reptiles of the secondary period, some of which attained a length of 180 feet or more, and amongst mammals in the extinct Tinoceras and the still surviving elephants and whales.

Comparative anatomists are familiar with similar phenomena exhibited by individual organs, such as the extraordinary development of horns and spines on many of the extinct reptiles referred to, the gigantic and grotesque beak and helmet of the hornbill and the tusks of Babirusa.[2]

The exuberant development of some organs of this kind may possibly be attributed to the action of sexual selection, and indeed our daily experience of our own species seems to warrant us in believing that there is no limit to the grotesque results which may ensue from the unrestricted exercise of the æsthetic faculties by either sex, but it hardly seems reasonable to attempt to explain all such bizarre and monstrous productions in this manner.

In all the cases cited, and in many others which could be adduced, either the entire body or some particular organ appears to have acquired some sort of momentum, by virtue of which it continues to grow far beyond the limits of utility, although perhaps in some cases a new use may be found which will assist the species in maintaining itself in the struggle for existence. An enormous increase of mere bodily size, however, seems in the long run to be always fatal to the race, whose place will be taken by smaller and presumably more active forms. The gigantic amphibians are all extinct, so are all the really gigantic reptiles, and of the gigantic mammals only a couple of species of elephants and a few whales survive, all of which are being rapidly exterminated in competition with man.

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[1] Vide Dr. Smith Woodward's Presidential Address to the Geological Section of the British Association, 1909.

[2] Darwin supposed that these tusks, which are curved backwards in such a position as to render them useless as weapons of offence, might still be defensive and used to parry blows, but this hardly seems a sufficient explanation of their enormous development.

Is there any justification in recent developments of biological science for the belief that a race of animals may acquire a momentum of the kind referred to which may ultimately lead it to destruction? Is there some brake normally applied to the growth of organisms and organs, and if so, are there occasions on which the brake may be removed, leaving the organism to rush to destruction like a car running away downhill? I hope to be able to show some ground for believing that both these questions may be answered in the affirmative.

It is, I think, now generally accepted by physiologists that the growth of the different parts of the animal body is controlled by internal secretions or hormones, the products of various glands. Thus we know that disease of the pituitary body in man leads to acromegaly, one of the symptoms of which is great enlargement of certain parts. The most dreadful of all diseases to which human beings are liable, cancer, is essentially due to an unrestrained multiplication of cells, and consequent abnormal growth of tissue, which may very possibly be correlated with the extent to which some specific controlling secretion is produced in the body. In short, we are justified in believing that, in the individual, growth is normally inhibited or checked by specific secretions and that in the absence of these it will continue far beyond the ordinary limits.

The question next arises, Can we apply this principle to the race as well as to the individual? I see no reason why we should not do so, and, paradoxical as it may seem, I think we may be able to explain the growth of the organism as a whole, and of its various organs, beyond the limits of utility, as an indirect result of natural selection.

When a useful organ, such as the tusk of a wild boar, is first beginning to develop, or to take on some new function for the execution of which an increase in size will be advantageous, natural selection will favour those individuals in which it grows most rapidly and attains the largest size in the individual lifetime. If growth is normally checked and controlled by some specific secretion, natural selection will favour those individuals in which the glands which produce this secretion are least developed, or at any rate least active. This process being repeated from generation to generation, these glands (whatever may be their nature, and we may use the term gland for any cell or group of cells which produces a specific secretion, whether recognisable as a distinct organ or not) may ultimately be eliminated, or at any rate cease altogether to produce the particular hormone in question. Moreover, this elimination may take place long before the organ whose growth is being favoured by natural selection has reached the optimum size. When it has reached this optimum it is certainly desirable that it should grow no larger, but there is no longer any means by which the growth can be checked: the inhibiting hormone is no longer produced, the brake has been removed, and further growth will take place irrespective of utility, until, when the size of the organ gets too great to be compatible with the well-being of the individual, natural selection again steps in and eliminates the race. The same argument of course applies to the size of the body as a whole, as well as to that of its constituent organs. Is it not possible that, the normal checks to growth

being thus removed along certain lines by the action of natural selection, a definite direction may be given to the course of evolution which the organism will continue to follow irrespective of natural selection?

I shall probably be told that all organs vary, and that when any particular organ has reached the optimum size natural selection will prevent it from going further by eliminating the unfavourable variations, *i.e.*, those which exhibit further increase. It may be admitted that the organ in question will probably exhibit variation in size after reaching the optimum, due to differences in nutrition and other peculiarities of the individual environment; but I fail to see how, in the absence of the gland which produces the specific controlling secretion, and which we have assumed to have been already eliminated, there are likely to be any variations of a *minus* character suitable for natural selection to work upon. In other words, it appears to me probable that natural selection, having once let go her control of growth, would be unable to regain it. In order that she might do so it would be necessary either that the glandular organ which originally produced the inhibiting hormone should be again developed or that some other organ should take its place. It is, however, generally admitted that an organ once lost is never redeveloped, and it does not seem likely that any other glandular organ, which we may suppose to be already occupied in producing a specific secretion for some other purpose, would be able to take on new duties and provide the necessary control before it was too late to save the organism from destruction.

If there is a possibility of any cumulative effect from generation to generation there seems no reason why, under these circumstances, increase of size should not continue indefinitely until it becomes incompatible with existence. Have we any right to assume any such cumulative effect? I think we have, for we know very well that the whole ontogeny of any one of the higher animals is nothing but the accumulation of a number of successive stages which have been added one after the other in the individual lifetimes of past generations. This at any rate is the teaching of the recapitulation hypothesis, in the truth of which I, for one, am a convinced believer. We also know from the facts of embryology that as each successive stage is added there is a tendency both towards an increase in the length of time occupied in development and also towards compression and abbreviation of the earlier stages so as to make room for new chapters of the record.

It seems, therefore, not unreasonable to assume that any increment in size which is gained by an individual animal or one of its organs before the period of reproduction, or before the germ cells which will give rise to the next generation are matured, and which is the result of the removal of some controlling factor, will tend to be inherited in the offspring in a cumulative fashion. If not, why have other features in the ancestral history been accumulated by heredity? It may be said that after the maximum rate of growth has once been attained there will be no further increase in the size of the organ, but I think there will, if only because there will be a slightly increased time available, owing to the lengthening of the period of development, in which growth may

take place. Then, even if there is no further acceleration of the actual rate of growth after the controlling influence has once been completely removed, the lengthening life-history will still afford opportunities for increase of size. It seems not impossible, however, that acceleration might also continue in connection with the shortening up of the stages of development in the ontogeny.

I should like to meet in advance another objection which may be raised to the views herein advocated. It may be urged that many of the bizarre and almost monstrous characters under discussion, such, for example, as some of the excrescences of the dermal armature in extinct reptiles, can never have had any value as adaptations, and that therefore natural selection could never have encouraged them to increase so much in size as to get beyond her control. Here, however, the principle of correlation comes in. Just as many different parts of the body are affected by disease of the pituitary gland, so the removal of the gland which controlled the development of some undoubtedly useful organ, such as a frontal horn, might at the same time permit the growth of all sorts of excrescences which have no adaptive significance.

I need hardly say that I have no wish to speak dogmatically with regard to the cause of that remarkable momentum which organisms certainly seem in many cases to acquire during the course of their evolution. Our knowledge of internal secretions and their specific action upon the different parts of the body is still in its infancy, indeed it has hardly commenced, but I venture to point out to biologists a possible clue to what has been for a long time an insoluble enigma. I hope that my suggestion will be freely criticised and that it may give rise to a discussion from which some grain of truth will ultimately emerge.

On Heat Coagulation of Proteins. *By* HARRIETTE CHICK, *D.Sc.*, and C. J. MARTIN, *M.B.*, *D.Sc.*, *F.R.S.*

[Ordered by the General Committee to be printed *in extenso.*]

ON heating solutions of many proteins an irreversible change of state occurs, so-called 'heat coagulation.' It has been the practice to regard the temperature at which this occurs as if it were a physical constant characteristic of the particular protein, although Duclaux and others have criticised this view.

This manner of regarding the matter is entirely misleading, for, as will be shown, 'heat coagulation' is a reaction between the protein and hot water in which heat plays the merely subsidiary part of an accelerator.

Heat coagulation consists of two separate phenomena—(1) a chemical transaction between protein and water (denaturation); (2) a subsequent aggregation of the altered protein complexes so as to form a precipitate (agglutination) or gel. The second stage may be in abeyance, although the first has occurred. By adjusting the conditions we have been able to study these two stages in the process apart from each other.

Denaturation.

Water as such, or in the form of steam, is essential for denaturation, for proteins in the dry condition can be heated to 150° C. (Michel and Wichmann) without change. We found that crystallised egg alb. suffered no change on heating to 120° C. for five hours in the dry state, and that methæmoglobin was unaltered after four hours at 110° C.

The reaction rate of denaturation.

Protein sols were placed in a test tube of 200 c.c. capacity, fitted with a stirrer of bent glass tube. The upper end of the stirrer passed through a glass bearing in the rubber cork and served also for the withdrawal of samples. The whole apparatus was immersed in a thermostat, which could be maintained at any desired temperature.

At definite intervals after the solutions had taken the temperature of the bath, samples were withdrawn and the content of protein still in solution determined.

The conditions of the experiments were so adjusted that the second process—agglutination of the denaturated protein—had a much higher velocity than the denaturation, so that the rate of this latter was the limiting factor.

Two proteins, hæmoglobin and egg albumen, both of which had been purified by re-crystallisation, were investigated. In the case of the

former, the residual protein was determined colorimetrically; and in the case of the latter, by boiling a definite volume, and collecting, washing, drying, and weighing the precipitate.

Hæmoglobin 3 per cent. solution.—Experiments were made at five temperatures between 60° and 70°·4 C. From the hæmoglobin remaining in solution in samples withdrawn after various intervals of time, the velocity constant was calculated on the assumption that the rate of reaction was merely dependent upon the concentration of unchanged protein at any particular moment.

$$\frac{1}{t - t_0}(\log c_0 - \log c) = k.$$

In all cases the calculated and observed values were in excellent agreement. There is, therefore, no doubt that in the case of this protein the reaction, although multi-molecular, is one of the first order, and that, water being in excess, it proceeds as if it were a unimolecular one.

Egg albumen 1 per cent. solution.—Similar experiments with egg albumen at temperatures between 69° and 76° C. gave results such that when residual concentrations were plotted against time they all lay upon smoothed curves. An examination of the figures, however, showed that the relation of residual concentration to time did not follow the same simple logarithmic law as had obtained with hæmoglobin. In these experiments the value obtained for k was not constant, but decreased progressively during the course of the experiments.

A reason for this departure soon became apparent. The reaction rate is sensitive to small changes in the hydrogen-ion concentrations, and as, for reasons which will be discussed later, hydrogen-ion concentration diminishes during the course of coagulation, the pure effect of the concentration of protein upon the reaction rate is obscured. We ultimately eliminated this disturbing factor by conducting the experiments in the presence of excess of a solid acid, which was only slightly ionised in solution. This provided us with a reservoir of acid, and maintained a constant acidity. For the purpose, we employed boracic acid, which, at 56° C., afforded us a degree of acidity with which we could work.

Under these conditions the reaction proceeded logarithmically.

Temperature and denaturation.

The effect of temperature upon the velocity of this reaction was determined by comparing the velocity constants at various temperatures. Only a comparatively small range could be studied (60° to 70°·4 for hæmoglobin and 69° to 76° C. for egg albumen) owing to the extraordinarily high temperature coefficient possessed by the reactions. The results were in both cases in good agreement with the law of Arrhenius.

$$\mu = \left(\frac{2T_0T_n}{T_0 - T_n}\log\frac{K_0}{K_n}\right).$$

The mean logarithmic difference in velocity per 1° C. was extraordinarily high, viz., 0·113 for hæmoglobin and 0·28 for egg albumen, or, in other words, an increase in rate of 1·3 and 1·9 times respectively per degree Centigrade rise in temperature.

Effect of acidity on rate of denaturation.

The effect of varying the acidity of the solution upon reaction rate was studied with egg albumen. Direct measurements of the hydrogen-ion concentration had to be made, as the protein combines with the acid to form salts. The effect of very small modifications in acidity is great and is not consistent; for example, on altering the H^+ concentration from 25 to 50×10^{-7} normal, the reaction rate was doubled, whereas a change from 125 to 250×10^{-7} normal trebled the velocity. This accelerating effect of acid accounts for the old observation that addition of acid lowers the coagulation temperature.

Progressive diminution of acidity during the denaturation of egg albumen.

A solution of egg albumen was maintained at a constant temperature and samples withdrawn from time to time. The determination of protein content and hydrogen-ion concentration of the samples showed that the acidity progressively diminished as the albumen was precipitated. An idea of the extent of this diminution may be formed from the following instance:—

A 1 per cent. solution of egg albumen had an original acidity of 135×10^{-7} normal before heating. In a sample withdrawn during the course of the experiment which contained 0·3 per cent. residual albumen the acidity was reduced to one-seventh ($19 \cdot 6 \times 10^{-7}$ normal).

As this fall of concentration of free acid is associated with a corresponding diminution in the velocity with which denaturation occurs it is clear why this was a disturbing factor in our earlier attempts to determine the relation of rate of reaction to concentration of protein.

The effect of acid on the reaction rate suggests that protein-acid-salts are denaturated more readily than protein itself and that the more acid the protein is combined with, the quicker the reaction.

We have ascertained that the acid is actually removed from the solution with the protein precipitate.

If this view of the effect of acid be accepted, a simple interpretation of the progressive diminution of acidity during denaturation is forthcoming. In a solution of protein to which a small amount of, say, hydrochloric acid has been added, the acidity represents the hydrolysis of the protein-HCl *plus* the electrolytic dissociation of the H of the carboxyl groups of the protein.

Disregarding for the present the latter, we have—

$$\text{Protein HCl} \rightleftarrows \text{Protein} + \text{HCl} \rightleftarrows \text{Protein} + H^+ + Cl^-.$$

If protein-HCl is removed a readjustment of equilibrium must occur. This is brought about by combination of some of the free protein and

HCl, and a diminution of acidity results which will obviously be progressive. The acidity due to the dissociated carboxyl groups will also diminish as the concentration of protein diminishes.

Effect of neutral salts upon rate of denaturation.

Experiments on the influence of neutral salts, NaCl + Am_2So_4, upon the velocity with which denaturation takes place were made by the method described above.

The concentration of salts in the solution varied between $\frac{1}{10}$ and three times normal. The residual albumen after different times at 71° C. was determined in the various solutions and plotted against time. Smooth curves were drawn through the observational points. From the curves it appears that in a concentration of NaCl equal to normal the rate was about $\frac{1}{20}$ and in twice normal about $\frac{1}{280}$ of that in the control. The effect of Am_2So_4 was somewhat less.

The second phase of heat coagulation; agglutination of the denaturated particles.

Unless the content of a protein solution as regards salts and acid be adjusted within certain definite limits, before boiling, the denaturated protein cannot be separated by filtration through paper. The solution assumes a milky or opalescent appearance, but the particles exhibit little or no tendency to agglutinate. Every grade of dispersion may be prepared by suitable manipulation of acid and salt. For reasons which will appear in the sequel, denaturated serum proteins aggregate less readily than egg proteins.

The effect of various acids on the aggregation of particles of denaturated serum proteins.

Known volumes of solutions containing about 0·3 per cent. of serum proteins and varying amounts of $\frac{N}{100}$ hydrochloric, acetic, or butyric acid were boiled and filtered through paper. In the event of any precipitate being caught by the paper this was washed, dried, and weighed. By this means the amount of denaturated protein sufficiently aggregated to be removed by a filter-paper was ascertained.

The results showed that until a particular addition of acid (which was the same for the three), had been made, no protein was held back by the filter-paper. At a higher concentration of all three acids complete agglutination occurred so that the filtrate was proteid free. Complete agglutination was also maintained in those samples to which a little more acid had been added, but was partial or did not occur in the samples to which still more acid had been added. There was a striking difference in the maximal amounts of the different acids after the addition of which complete separation of the protein could be effected. Excess of hydrochloric suspended agglutination more readily than excess of acetic, and excess of acetic acid more readily than excess of butyric.

Experiments with egg albumen gave analogous results. In both cases there is only a narrow range within which aggregation of the denaturated particles occurs (optimum acidity of Michaelis and Rona). With too much or too little no agglutination occurs. The fact that the weakest acid gave the largest range suggested that the phenomenon was conditioned by acidity rather than acid added.

On repeating the experiments with determination of hydrogen-ion concentration this was shown to be the case. The range of acidity corresponding to complete agglutination was with all three acids the same (0·5 to 1·5 × 10^{-5} normal).

The effect of salts upon agglutination.

The effect of salts (NaCl, Am_2So_4, $Na_2\ So_4$) upon the agglutination of denaturated egg albumen and serum albumen is the exact opposite. Whereas the presence of salts facilitates the agglutination of the particles of altered egg albumen, it disperses those of serum proteins.

The agglutinating effect of acidity, salt content, &c., can be most conveniently studied in solutions of egg albumen or serum proteins which have previously been boiled in their natural reaction. Subsequent adjustment of the acidity or salt content brings about agglutination and complete precipitation of the proteins. Using such material we have estimated the influence of salts upon the velocity of agglutination by determining the time taken for visible particles to appear at 37° C., taking the reciprocal of this time as an index of agglutination rate.

Employing this method it was found that concentration of NaCl up to 0·1 per cent. exerts little effect, but beyond this the effect becomes very marked. With serum albumen the rate of agglutination is progressively lowered, and with egg albumen progressively increased.

Effect of temperature on agglutination rate.

The effect of temperature is peculiar. For each particular concentration of salt and acidity there is a critical temperature below which agglutination does not occur. As the temperature is increased the rate rises very greatly at first, and then less and less until at temperatures well removed from the critical one the influence of rise in temperature is consistently to multiply the rate two to three times per 10°C.

Theoretical considerations regarding the above facts concerning agglutination.

Whether particles cohere depends primarily upon their curvature (size) and the magnitude of the surface tension between them and the solution. The electric condition of the particles is also of importance, not only because, if these are charged, the surface tension is diminished (Helmholtz-Bredig effect), but because the possession of a charge of like kind leads to repulsion. This force of repulsion must be overcome before the particles can be brought sufficiently near one another for surface action to be effective.

Proteins become charged by the electrolytic dissociation of the hydrogen of the carboxyl group. Their salts, with acids and bases, are also electrolytically dissociated. In the case of the salts with acids the charge carried by the protein is of opposite sign to that caused by the dissociation of the hydrogen of its carboxyl groups, so that the protein may be less or more positively charged, according to the degree to which salt formation has occurred (the acidity of the solution), or, if the two effects balance, uncharged (iso-electric point).

At the iso-electric point the maximum surface tension between particle and liquid and the minimum repulsion between particle and particle will exist, hence this is the optimum point for agglutination. In the presence of alkali ($H+$ concentration less than 10^{-7} N) agglutination cannot occur, as the negative charge on the protein is sufficient to keep the particles apart.

Before attempting to explain the peculiar effect of temperature on agglutination, we must mention that we could only study this effect under circumstances which were not entirely favourable to agglutination, *i.e.*, when it took place slowly. In our experiments the surface tension was small, and the particles were always charged, and therefore repelled one another. In order that this small surface energy may be effective, the particles must be brought within a very small distance of one another. The necessary translation is effected by their own intrinsic energy (Brownian movement), but until the temperature rises to a certain point the mean velocity of the particles is insufficient to overcome the repulsion due to the charges. Once that temperature at which some of the particles possess the requisite velocity is exceeded, the effect of temperature is for the time being very great owing to the way in which the velocities of the individual particles are distributed about the mean, which in this case we may suppose to be normal. At temperatures higher than that at which all, or nearly all, the particles possess the requisite velocity, temperature will influence agglutination rate only to the degree to which it enhances mean molecular energy, viz., two to three times per 10° C. rise.

The Claim of Sir Charles Bell to the Discovery of Motor and Sensory Nerve Channels (an Examination of the Original Documents of 1811 to 1830). By AUGUSTUS D. WALLER, *M.D., F.R.S.*

[Ordered by the General Committee to be printed *in extenso.*]

CONTENTS.

I. THE anatomical distinction between motor and sensory nerves was an event of capital magnitude in the history of physiology; it stands on a par with the proof of the systematic circulation given by Harvey two centuries before.

The date and the authorship of the more recent discovery are not yet authoritatively settled. Charles Bell 1811, François Magendie 1822, are the two names and dates between which a decision must still be made.

An opinion prevails very generally—not only in England but also in Germany and in France—that the credit of the discovery belongs to Charles Bell. That opinion is in part based upon a 'Report on the Physiology of the Nervous System,' by William Charles Henry, M.D., received by the British Association in the year 1833, and containing the following sentence: 'The honour of this discovery, doubtless the most important accession to physiological knowledge since the time of Harvey, belongs exclusively to Sir Charles Bell.'

I submit that this statement, which has been widely accepted without examination and widely repeated, is not justified by previous scientific publications. The careful examination of those publications has forced upon me the conclusions that the discovery was made by Magendie in 1822, and that the claims made to it by Charles Bell and his relations in 1823 and 1824 so far from being proved are in fact completely disproved by the documents themselves.

II. The principal ground upon which the distinction between motor and sensory nerves was made consisted in experiments on the anterior and posterior spinal roots. Subsidiary evidence leading to the same fundamental distinction consisted in experiments and observations on the fifth and seventh nerves.

The documents belonging to these two provinces have to be examined separately and considered conjointly.

As regards the spinal roots, the documents to be examined are:—

A.—Charles Bell, 1811: 'Idea of a New Anatomy of the Brain.' Submitted for the observations of his friends by Charles Bell, F.R.S.E. Small octavo, pp. 36, published by Strachan & Preston, printers, London: without date, but on collateral evidence the date 1811 is accepted; Bell's annotated copy is in the Library of the Royal Society; his presentation copy to Sir Joseph Banks is in the Library of the British Museum.

B.—François Magendie, 1822: 'Expériences sur les Fonctions des Nerfs Rachidiens'; 'Journal de Physiologie Expérimentale et Pathologique,' par F. Magendie. Tome 11, Année 1822, pp. 276-9.

As regards Bell's 'Idea' of 1811, the most careful reading entirely fails to bring to light any paragraph or any allusion indicative of a distinction between motor and sensory functions of nerve-roots. The distinction he draws is between cerebral and cerebellar roots, the former subserving the functions of animal life—*i.e.*, the obvious motor manifestations of sensation, the latter the functions of nutrition or vegetative life, or, as he expresses it, 'the secret operations of the bodily frame.' And the only description of an experiment consists in the following sentence:—

> P. 22.—On laying bare the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow without convulsing the muscles of the back, but that on touching the anterior fasciculus with the point of the knife the muscles of the back were immediately convulsed.

No details are given; we do not learn from this description what was the animal used nor whether it was alive or dead. It is only from a subsequent allusion made by Bell at page 29 of 'An Exposition of the Natural System of Nerves of the Human Body,' published in 1824, that we learn that the description applies to a rabbit stunned—*i.e.*, killed by a blow behind the ear. And in the interval between 1811 and 1824 Bell, as he says himself, made no other experiment on the nerve-roots.

It is imagined that Bell interpreted the result of this experiment as meaning that the anterior root was motor and the posterior root sensory. But it is clear to anyone having read what Bell wrote in the 'Idea' that he took the result to mean that the anterior and manifestly sensitive root was cerebral and the posterior insensitive root cerebellar.

Clearly the distinction between motor and sensory nerves was not established nor even thought of by Bell in 1811. The whole of the 'Idea' is purely speculative upon lines leading anywhere except in that direction, and contains no experiment pointing towards it. During the next ten years, from 1811 to 1821, Bell did and said nothing more about the nerve-roots.

In 1821, at the age of forty-seven, he communicated the first of a series of six papers to the 'Philosophical Transactions' of the Royal Society, to which we shall refer in a moment, as forming the documentary record of his scientific title as a physiologist. Of these six papers the first is the most important, dealing with the nerves of the face, and published in 1821—*i.e.*, before the publication by Magendie of his own experiments on the spinal roots.

The best passages that can be quoted on the side of Bell from the 'Idea' of 1811 are as follows:—

> Page 21.—I took this view of the subject. The *medulla spinalis* has a central division, and also a distinction into anterior and posterior fasciculi, corresponding with the anterior and posterior portions of the brain. Further, we can trace down the crura of the *cerebrum* into the anterior fasciculus of the spinal marrow, and the crura of the *cerebellum* into the posterior fasciculus. I thought that here I might have an opportunity of touching the *cerebellum*, as it were, through the posterior portion of the spinal marrow, and the cerebrum by the anterior portion. To this end I made experiments which, though they were not conclusive, encouraged me in the view I had taken.
>
> I found that injury done to the anterior portion of the spinal marrow convulsed the animal more certainly than injury done to the posterior portion; but I found it difficult to make the experiment without injuring both portions.
>
> Next considering that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connections with the parts of the brain, I thought that I had an opportunity of putting my opinion to the test of experiment, and of proving at the same time that nerves of different endowments were in the same cord, and held together by the same sheath.
>
> On laying bare the roots of the spinal nerves, I found that I could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed.
>
> Such were my reasons for concluding that the cerebrum and the cerebellum were parts distinct in function, and that every nerve possessing a double function obtained that by having a double root. I now saw the meaning of the double connection of the nerves with the spinal marrow; and also the cause of that seeming intricacy in the connections of nerves throughout their course, which were not double at their origins.
>
> The spinal nerves being double, and having their roots in the spinal marrow, of which a portion comes from the cerebrum and a portion from the cerebellum, they convey the attributes of both grand divisions of the brain to every part; and therefore the distribution of such nerves is simple, one nerve supplying its destined part. But the nerves which come directly from the brain come from parts of the brain which vary in operation; and in order to bestow different qualities on the parts to which the nerves are distributed, two or more nerves must be united in their course or at their final destination. Hence it is that the 1st nerve must have branches of the 5th united with it: hence the *portio dura* of the 7th pervades everywhere the bones of the cranium to unite with the extended branches of the 5th: hence the union of the 3rd and 5th in the orbit: hence the 9th and 5th are both sent to the tongue: hence it is, in short, that no part is sufficiently supplied by one single nerve, unless that nerve be a nerve of the spinal marrow, and have a double root, a connection (however remotely) with both the cerebrum and cerebellum.
>
> Page 26.—The *cerebellum* when compared with the *cerebrum* is simple in its form. It has no internal tubercles or masses of cineritious cortex, and forms the *crus*; and the *crus* runs into union with the same process from the *cerebrum*; and they together form the *medulla spinalis*, and are continued down into the spinal marrow; and these crura or processes afford double origin to the double nerves of the spine. The nerves proceeding from the Crus Cerebelli go everywhere (in seeming union with those from the Crus Cerebri); they unite the body together, and control the actions of the bodily frame; and especially govern the operation of the viscera necessary to the continuance of life.
>
> Page 27.—The cerebrum I consider as the grand organ by which the mind is united to the body. Into it all the nerves from the external organs of the senses enter; and from it all the nerves which are the agents of the will pass out.
>
> Page 36.—The secret operations of the bodily frame, and the connections which unite the parts of the body into a system, are through the cerebellum and nerves proceeding from it.

It would serve no useful purpose to reproduce *in extenso* Bell's 'Idea' of 1811, all that could be shown by such a reproduction is that it is of very little scientific value; the best that can be done for it has been done by quoting its least unsatisfactory portions. Moreover, the requirements of anyone desiring to satisfy his mind as to its full contents and unable to do so at the British Museum or at the Royal Society are met by accurate reprints made of it in 'Documents and Dates,' published by A. Walker in 1839, and in Turner's 'Journal of Anatomy' for 1869 (p. 147).

On the other hand, the next document, that published by Magendie, must be given *in extenso* if only to allow the reader to judge for himself whether or no it includes any redundancy or inaccuracy of description:—

Expériences sur les fonctions des racines des nerfs rachidiens.

Depuis longtemps je désirais faire une expérience dans laquelle je couperais sur un animal, les racines postérieures des nerfs qui naissent de la moelle épinière. Je l'avais tentée bien des fois, sans pouvoir y réussir, à cause de la difficulté d'ouvrir le canal vertébral sans léser la moelle, et par suite sans faire périr ou tout au moins sans blesser grièvement l'animal. Le mois dernier, on apporta dans mon laboratoire, une portée de huit petits chiens âgés de six semaines; ces animaux me parurent très propres à tenter de nouveau d'ouvrir le canal vertébral. En effet, je pus à l'aide d'un scalpel bien tranchant, et pour ainsi dire d'un seul coup, mettre à nu la moitié postérieure de la moelle épinière entourée de ses enveloppes. Il ne me restait pour avoir cet organe presqu'à nu, que de couper la dure-mère qui l'entoure: c'est ce que je fis avec facilité; j'eus alors sous les yeux les racines postérieures des paires lombaires et sacrées, et en les soulevant successivement avec les lames de petits ciseaux, je pus les couper d'un côté, la moelle restant intacte. J'ignorais quel serait le résultat de cette tentative; je réunis la plaie par une suture à la peau, et j'observai l'animal; je crus d'abord le membre correspondant aux nerfs coupés, entièrement paralysé; il était insensible aux piqûres et aux pressions les plus fortes, il me paraissait aussi immobile; mais bientôt, à ma grande surprise, je le vis se mouvoir d'une manière très apparente, bien que la sensibilité y fût toujours tout-à-fait éteinte. Une seconde, une troisième expérience, me donnèrent exactement le même résultat; je commençai à regarder comme probable que les racines postérieures des nerfs rachidiens pourraient bien avoir des fonctions différentes des racines antérieures, et qu'elles étaient plus particulièrement destinées à la sensibilité.

Il se présentait naturellement à l'esprit de couper les racines antérieures, en laissant intactes les postérieures; mais une semblable entreprise était plus facile à concevoir qu'à exécuter; comment mettre à découvert la partie antérieure de la moelle, sans intéresser les racines postérieures? J'avoue que la chose me parut d'abord impossible; cependant je ne cessai d'y rêver pendant deux jours, et enfin je me décidai à essayer de passer devant les racines postérieures, une espèce de couteau à cataracte, dont la lame, très étroite, permettrait de pouvoir couper les racines, en les pressant avec le tranchant de l'instrument, sur la face postérieure du corps des vertèbres; mais je fus obligé de renoncer à cette manœuvre, à cause des grosses veines que contient le canal de ce côté, et que j'ouvrais à chaque mouvement en avant. En faisant ces essais, je m'aperçus, qu'en tirant sur la dure-mère vertébrale, on pouvait entrevoir les racines antérieures réunies en faisceaux, au moment où elles vont percer cette membrane. Il ne m'en fallut pas davantage, et en quelques instans, j'eus coupé toutes les paires que je voulais diviser. Comme dans les expériences précédentes, je ne fis la section que d'un seul côté afin d'avoir un terme de comparaison. On conçoit avec quelle curiosité je suivis les effets de cette section: ils ne furent point douteux, le membre était complètement immobile et flasque, tandis qu'il conservait une sensibilité non équivoque. Enfin, pour

ne rien négliger, j'ai coupé à la fois les racines antérieures et les postérieures; il y a eu perte absolue de sentiment et de mouvement.

J'ai répété et varié ces expériences sur plusieurs espèces d'animaux: les résultats que je viens d'énoncer se sont confirmés de la manière la plus complète, soit pour les membres antérieurs, soit pour les postérieurs. Je poursuis ces recherches et j'en donnerai un récit plus détaillé dans le prochain numéro; il me suffit de pouvoir avancer aujourd'hui comme positif, que les racines antérieures et les postérieures des nerfs qui naissent à la moelle épinière, ont des fonctions différentes, que les postérieures paraissent plus particulièrement destinées à la sensibilité, tandis que les antérieures semblent plus spécialement liées avec le mouvement.

III. *The Fifth and Seventh Nerves.*—We have now to examine the second or subsidiary ground upon which Bell's claim to have discovered the distinction between motor and sensory nerves has been placed, viz., the motor and sensory functions of the fifth and seventh nerves.

The issue in this case, while sufficiently distinct, cannot be presented with the same brevity and simplicity as was possible in the case of the nerve-roots. It is not a simple issue in which only Bell and Magendie are concerned; it rests directly between Bell and Mayo; Magendie is only indirectly concerned in so far as his discovery of 1822 concerning the spinal roots modified and cleared up the views both of Bell and Mayo as to the sensory and motor functions of the facial nerves. This was fully acknowledged by Mayo; it is obviously recognisable in Bell's publications. Finally as regards the anatomy and physiology of the nerves of the face it will also be necessary to take into account the work of the Italian investigator Bellingeri, who in 1819 presented to the Royal Society a copy of his dissertation of 1818 in which the motor and sensory functions of the fifth nerve and the motor functions of the seventh nerve are clearly recognised and described.

Bell in 1821 communicated his first paper to the Royal Society:—

(1) 1821. 'On the Nerves: Giving an Account of Some Experiments on their Structure and Functions, which lead to a New Arrangement of the System,' by Charles Bell, Esq. Communicated by Sir Humphry Davy, Bart., P.R.S. Read July 12, 1821.—'Philosophical Transactions of the Royal Society,' 1821, part II., pp. 398-424.

In the following year he communicated a second paper:—

(2) 1822. 'Of the Nerves which Associate the Muscles of the Chest in the Actions of Breathing, Speaking, and Expression: Being a Continuation of the Paper on the Structure and Functions of the Nerves,' by Charles Bell, Esq. Communicated by Sir Humphry Davy, Bart., LL.D., P.R.S. Read May 2, 1822.—'Phil. Trans. R.S.,' 1822, Part II., pp. 284-312.

These two papers antedate Magendie's publication of 1822, and any information concerning the distinction between the sensory and motor portions of the fifth nerve, or any clear definition of the motor character of the portio dura of the seventh nerve, would justify us in reckoning Bell as having participated with Magendie in the discovery of the distinction between motor and sensory nerves.

But the papers in question contain no such information or definition. On the contrary it is evident that at that time, *i.e.*, in 1821 and 1822,

the fifth nerve in Bell's thought was as a whole a mixed nerve like a spinal nerve, and that the portio dura of the seventh was a peculiar superadded nerve subserving facial movements associated with the function of respiration.

Apart from the singularity of Bell's presentation of the respiratory system of nerves, his precise meaning in 1821 and 1822 is not easily gathered. In the comparatively simple case of the fifth nerve, it is impossible to assure oneself of Bell's real meaning. His description of its functions is confused and confusing, and all that can be said of it is that it does not contain the distinction commonly attributed to him of the motor and sensory roots of the fifth nerve.

Magendie's discovery was published in 1822—dealing with the motor and sensory functions of the spinal roots.

Bell immediately claimed the discovery as his, and John Shaw forwarded his claim to Magendie accompanied by a copy of the 'Idea' of 1811.

In 1823 Bell communicated two further papers to the Royal Society:—

(3) 1823. 'On the Motions of the Eye, In Illustration of the Uses of the Muscles and Nerves of the Orbit,' by Charles Bell, Esq. Communicated by Sir Humphry Davy, Bart., P.R.S. Read March 20, 1823.—'Phil. Trans. R.S.,' 1823, p. 166.

(4) 1823. 'Second Part of the Paper on the Nerves of the Orbit,' by Charles Bell, Esq. Read June 19, 1823.—'Phil. Trans. R.S.,' 1823, p. 289.

From our present standpoint these two papers are of significance only in so far as they contain a clear and correct account of the sensory and motor functions of the two portions of the fifth nerve, and a passage in which he protests that experiments have never been the means of discovery and invokes the examples of our own great countrymen as distinguished from those of France.

Both these passages, which are foreign to the subject of the paper in which they occur, are obviously inspired by the publications of Mayo and of Magendie, the latter of whom is named in a footnote (p. 307).

1. *Bellingeri's Inaugural Dissertation of* 1818.—The clear understanding arrived at in England in 1822-23 concerning the motor and sensory functions of the two portions of the fifth nerve was, as is stated in Dr. Henry's 'Report to the British Association' in 1833, principally due to Mayo. Bell, to whom the discovery was subsequently attributed, did not come near it in 1821, and only pretended in 1824 to have done so. We have seen that his pretension was unfounded.

But before either Mayo or Bell, and before Magendie's illuminating discovery of 1822, Bellingeri in 1818 had published a clear and exhaustive account of the fifth and seventh nerves, in which their anatomy and physiology are presented very nearly in accordance with our present knowledge.[1] As regards the fifth nerve, Bellingeri distinguishes clearly between the distribution and functions of its two portions to which he refers under the designations: *Portio major quinti paris vel nervus*

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[1] C. F. J. Bellingeri: *Dissertatio Inauguralis*, 1818, 8vo, pp. 337. Augustæ Taurinorum excudebat Joseph Favale. A copy of this book is in the Library of the Royal Society.

trifacialis and *Portio minor quinti paris vel nervus masticatorius*. He also describes very fully and accurately the applications of his knowledge to practical medicine. Tic douloureux is for him due to affection of the portio major, trismus to affection of the portio minor, and his description of the symptoms and pathology of facial palsy—*i.e.*, Bell's palsy, as it is now commonly termed—deserves to be quoted as the first classical account on record of this affection:—

Page 181, XLIII.—Pathologica mihi est septimi paris observatio. Decumbebat vir in noscomio Divi Joannis, eximii Professoris Geri curæ commissus, cui a longo tempore tumor inflammatorius erat pone auram dextram, et supra processum mastoideum, et infra extensus, ita ut nervum facialem in proprio exitu e foramine stylo-mastoideo comprimeret, sicuti et cel. Professoris, et Chirurgiæ Doctorum Gallo et Riberi opinio certa videbatur. Interim in ipso aegrotante universa fere musculorum dexteri lateris faciei observabatur paralysis, et oris in sinistram partem distortio. Perfecta scilicet erat paralysis musculi frontalis, supraciliaris, orbicularis palpebrarum, elevatoris alæ nasi, et labii superioris, canini, zygomatici, orbicularis labiorum in dextra parte, triangularis, et quadrati menti, et colli cutanei. Integer erat motus, aut levissime læsus, musculorum temporalis, masseterici, buccinatorii, pterygoideorum; de digastrico nullum ferre judicium potuimus. Globi oculi, et palpebræ superioris motus erat liber; læsus tamen aliquantisper visus in oculo dextero; lingua pariter cum aliqua difficultate movebatur, gustus nihilominus utroque in linguæ latere æque superstes, ut experimento sumus assecuti; pariter sensus tactus integer in facie, auditus quammaxime imminutus in dextra aure, sed apertus erat abscessus in aure externa. Periit post menses duos circiter. Inventum pus in cavo tympani effusum, in aquæductu Fallopii contentum, et facialem in ipsius transitu comprimens; nil puris post mortem, nec inflammationis vestigia circa foramen stylo-mastoideum; recentis vero inflammationis, et suppurationis indicia in dextro cerebelli lobo, integra atque illæsa quinti paris stamina et truncus.

I made the following observation on the seventh pair. A man was lying in the hospital of St. John committed to the care of Professor Gero, on whom for a considerable time there had been an inflammatory tumour behind the right ear and above the mastoid process, and extending downwards so that it compressed the facial nerve at its exit from the stylo-mastoid foramen, in the decided opinion of the celebrated Professor, and Doctors of Surgery Gallo and Ribero. In this patient there was observed paralysis of nearly all the muscles of the right side of the face, with a distortion of the mouth towards the left side. The paralysis was complete of the following muscles, viz.—the frontal, superciliary, orbicularis palpebrarum, of the elevator alæ nasi, of the elevator labii superioris, of the canine, of the zygomatic, and of the orbicular muscle of the lips on the right side, of the triangularis and the quadratum of the chin and of the cutaneous muscle of the neck. Motion was intact or very slightly affected in the temporal, masseteric, buccinator and pterygoid muscles; as regards the digastric we could come to no definite conclusion. There was free movement of the eyeball and of the upper eyelid. Vision was to some extent impaired in the right eye, and the tongue moved with some difficulty; taste was, however, equally preserved on both sides of the tongue, as was ascertained by experiment; the sense of touch was unimpaired over the face; hearing was as far as might be undiminished in the right ear, but the abscess was open on that side. About two months later the patient died. There was found to be effusion of pus in the tympanic cavity and in the aqueduct of Fallopius, compressing the facial nerve. There was no pus, nor sign of inflammation in the neighbourhood of the stylo-mastoid foramen; there were distinct signs of recent inflammation and of suppuration in the right lobe of the cerebellum; the main divisions and the trunk itself of the fifth pair were uninjured.

Bellingeri also gave a complete tabular summary of the branches of the two portions of the fifth nerve. His description of the

nerve of mastication, opposite page 118 of the 'Dissertation,' is as follows:—

NERVUS	Portio minor quinti paris, vel nervus masticatorius.
ORIGO	A cruribus cerebelli.
TRUNCUS	Crotaphiticus et Buccinatorius.
RAMI	Plexus gangliof. cum Maxillari inferiori.
SURCULI	(*a*)—Massetericus. (*b*)—Crotaphiticus. (*c*)—Buccinatorius. (*d*)—Pterygoideus.
FASCICULI	(*a*)—In plures fasciculos. (*b*)—Fasciculus externus. Fasciculus internus. (*c*)—Musculares. Glandulares. Buccalis. Bucco-labialis.
INSERTIONES	(*a*)—In articulationem maxillar., m. temporalem, massetericum. (*b*)—In fibras externas musculi crotaphitici. (*c*)—In mediam, et anteriorem partem musculi crotaphitici. In musculos pterygoideos, et musculum temporalem. In ductum stenonianum, et glandulas buccales. In musculum buccinatorium. In musculum buccinatorem, caninum et triangularem. (*d*)—In musculos pterygoideos.
USUS (page 177)	Spectat igitur portio minor quinti paris ad nervos vitæ animalis et quidem ad nervos motorios; nullibi enim sensibus præest, et habita ratione ipsius officii, *nervus masticatorius* esset dicendus.

2. *Mayo's Commentaries.*—Herbert Mayo, in his publications of 1822-23 ('Anatomical and Physiological Commentaries,' No. 1, August 1822; No. 2, July 1823), made a distinct contribution to our clearer knowledge of the fifth and seventh nerves, which is duly recognised in the 'Report to the British Association' of 1833.

> Mr. Herbert Mayo, in the admirable essay already referred to, was the first to point out the true relations of the fifth and seventh nerves.

His results were tacitly accepted by Bell and incorporated without acknowledgment in the 'Exposition' of 1824 and in the subsequent editions 1830 and 1836 of Bell's 'Nervous System,' which are the sources from which all subsequent accounts have been taken. This matter deserves to be rectified by reference to the original documents of 1821-22.

Mayo in the first number of his 'Commentaries' (1882) at p. 112 concludes from his experiments that in the ass the portio dura is a simple nerve of voluntary motion; that the frontal, infraorbital, and inferior maxillary branches of the fifth, are nerves of sensation only; and that other branches of the third division of the fifth are voluntary nerves to the pterygoid, the masseter, the temporal, and the buccinator muscles. He rejects Bell's description of the defective prehension by an ass after section of the superior maxillary branch of the fifth as being obviously due to want of *motion*, and attributes the defect to loss of *sensation*. (*N.B.*—Bell accepted the correction by altering the description of the experiment in later editions of his 'Nervous System' from

the words 'obvious loss of motion' to the words 'obvious loss of sensation,' but makes no mention of Mayo.)

In the second number of his 'Commentaries' (1823) at p. 9 Mayo is quite clear that the fifth consists of two portions, sensory and motor, and is led from the analogy between the fifth and the spinal nerves

> 'to conjecture that the double roots of the spinal nerves have functions corresponding with those of the fifth, and that the large posterior portion of each spinal nerve, with its ganglion, belongs to cutaneous sensation, and the anterior branch to voluntary motion. When I was engaged in experiments to determine the fact, M. Magendie's were published, which established the justness of my conjecture.'

Thus Mayo in 1823 and Bell in 1824 were clear about motor and sensory nerves in general, and about the fifth nerves in particular. But in 1821, *i.e.*, before Magendie's publication of 1822, neither Bell nor Mayo possessed any clear view as to the motor and sensory functions of the fifth or of any other mixed nerve.

Bell said at that time (' Phil. Trans. R S.,' 1821, p. 404):—

> 'The nerves of the spine, the tenth or sub occipital nerve, and the fifth or Trigeminus of the system of Willis, constitute this original and symmetrical system. All these nerves agree in these essential circumstances; they have all double origins; they have all ganglia on one of their roots; they go out laterally to certain divisions of the body; they do not interfere to unite the divisions of the frame; they are all muscular nerves; ordering the voluntary motions of the frame; they are all exquisitely sensible; and the source of the common sensibility of the surfaces of the body: when accurately represented on paper, they are seen to pervade every part; no part is without them; and yet they are symmetrical and simple as the nerves of the lower animals.
>
> If the nerves be exposed in a living animal, those of this class exhibit the highest degree of sensibility; while on the contrary, nerves not of this original class or system are comparatively so little sensible as to be immediately distinguished, insomuch that the quiescence of the animal suggests a doubt whether they be sensible in any degree whatever. If the *fifth nerve*, and the *portio dura* of *the seventh*, be both exposed on the face of a living animal, there will not remain the slightest doubt in the mind of the experimenter which bestows sensibility. If the nerve of this original class be divided, it in no measure deprives the parts of their sensibility to external impression.

At our present level of knowledge—1911—or even at the level of 1830 it is possible to read into this passage that Bell meant that the fifth is sensory and the seventh motor. But from the remainder of the paper it soon becomes evident to us that this was not his meaning in 1821, and that he was contrasting the sensibility of an original or regular nerve of animal life, *i.e.*, the fifth, with the insensibility of other nerves, *e.g.*, his respiratory system of nerves. He does not say that the portio dura is motor in contrast to the fifth sensory, but only that the portio dura is insensitive in comparison with the fifth, which is very sensitive. The distinction in his mind is similar to that by which he had been misled in 1810 in thinking about the nerve-roots, when he says:—

> 'It is almost superfluous to say that the part of the spinal marrow having sensibility comes from the *cerebrum*; the posterior and insensitive part of the spinal marrow belongs to the *cerebellum*. Taking these facts as they stand, is it not most curious that there should be thus established a distinction in the parts of a *nerve*, and that a nerve should be insensitive.'—'Letters,' p. 171.

The account given by Mayo of Bell's opinion *at that time* is, in my judgment, absolutely correct. Mayo says ('Outlines of Physiology,' second edition, 1829, p. 332):—

> 'The inference which Mr. Bell drew from these experiments was that the branches of the fifth, which emerge upon the face to supply the muscles and integuments, are for *sensation and voluntary motion jointly*; and that the use of the seventh (the branches of which are distributed to the same parts) is to *govern the motions of the lips, the nostrils, and the velum palati when the muscles of these parts are in associated action with the muscles of respiration.* In other words, according to Mr. Bell, the seventh is the nerve of instinctive motion to the face, and the fifth of voluntary motion and sensation.'

We must bear in mind that in this use of the term 'fifth nerve' both Bell and Mayo mean to denote '*portio major*' without definitely distinguishing from it (as they might have done on the strength of the publications of Soemmering and Palletta and Bellingeri) its '*portio minor*'—the nerve of mastication or motor root of the fifth. This distinction was a later development with Bell as with Mayo. The latter is perfectly candid on this point and expresses himself as follows ('Outlines,' p. 335):—

> 'In pursuing this subject, I was led to observe that there were muscles which received no branches from any nerve but the fifth; these muscles are the masseter, the temporal, the two pterygoids, and the circumflexus palati. These muscles again, I remarked, are supplied with branches from the third division of the fifth, that is to say, from the particular division of the fifth, with which *the smaller fasciculus or root of the nerve* is associated. After some careful dissection, in the greater part of which I afterwards found that I had been anticipated by Palletta, I made out that *the smaller fasciculus of the fifth* is entirely consumed upon the supply of the muscles I have named; to which it is to be borne in mind that twigs from the ganglionic portion of the nerve are likewise distributed.
>
> 'But I had already ascertained by experiment that almost all the branches of the larger or ganglionic portion of the fifth were nerves of sensation. I proved this point in the ass, the dog, and the rabbit, respecting the second and third division of the fifth; in the pigeon, respecting the first division. It was therefore thoroughly improbable that the twigs sent from the same part of the nerve to the muscles of the lower jaw should have a different quality, and be nerves of motion. For this function it was reasonable to look to the other nervous fibriles, which the masseter and temporal and pterygoid muscles receive, in other words, *to the branches of the smaller fasciculus or root or ganglionless portion of the fifth.*
>
> By the experiments and reasoning which I have described, I established that the ganglionless portion of the fifth and the hard portion of the seventh nerve are voluntary nerves to parts which receive sentient nerves from the larger or ganglionic portion of the fifth. This happened before the publication of M. Magendie's discovery of the parallel functions of the double roots of the spinal nerves; and without wishing to assert the least claim to that discovery, I will yet observe that I was led by the well-known anatomical analogy between the fifth and spinal nerves, to conjecture nearly what M. Magendie proved, and was indeed actually engaged in experiments to determine the point when M. Magendie's were published.'

IV. The passages in which Bell first alludes to the experiments of Magendie occur in his fourth paper on the 'Nerves of the Orbit,' in the 'Philosophical Transactions' for 1823, at pp. 306-7, and are as follows:—

> 'Anatomy is already looked upon with prejudice by the thoughtless and ignorant; let not its professors unnecessarily incur the censures of the humane.

> Experiments have never been the means of discovery; and a survey of what has been attempted of late years in physiology will prove that the opening of living animals has done more to perpetuate error than to confirm the just views taken from the study of anatomy and natural motions.
>
> 'Surely it is time that the schools of this kingdom should be distinguished from those of France. Let physiologists of that country borrow from us, and follow up our opinions by experiments (see the experiments of M. Magendie on the distinctions in the roots of the spinal nerves); but let us continue to build that structure which has been commenced in the labours of the Monros and Hunters.'

At this period, then, Bell was in full controversy; in the following year he hastens to publish a full account of his own discoveries under the title 'An Exposition of the Natural System of the Nerves of the Human Body, with a Re-publication of the Papers delivered to the Royal Society on the Subject of the Nerves,' by Charles Bell, Professor of Anatomy and Surgery to the Royal College of Surgeons; Teacher of Anatomy in the School of Great Windmill Street, and Surgeon to the Middlesex Hospital; 8vo. London: Printed by Eyre & Spottiswoode, 1824.

From our present historical standpoint this is by far the most important of Bell's publications, for it is in fact the first edition of Bell's 'Nervous System of the Human Body,' which in one or other of the two *Third Editions* of 1836 and 1844 is the source from which all subsequent writers have derived their information.[2]

The title-page of Bell's 'Exposition,' &c., of 1824, carries as its sub-title 'with a Re-publication of the Papers delivered to the Royal Society on the Subject of the Nerves.'

The preface (p. vi) states that the publication of the system in its premature state is made in order to remedy a systematic attempt to anticipate him and 'to assume whatever merit may belong to these discussions.'

The introduction of 66 pages substantially incorporates all the results published by Magendie and by Mayo during the two previous years, but does not once mention their names. The only passage that indicates to us the source of Bell's extension of knowledge is upon p. 2 as follows:—

> 'In France, where an attempt has been made to deprive me of the originality of these discoveries, experiments without number and without mercy have been

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[2] The edition of 1844 is a reprint of that of 1836. The second edition was published in 1830 as an 'Edition de Luxe' in quarto form for presentation to the King. Copies of the third edition are to be found in any library. The first edition (an exposition, &c.), is comparatively rare. There is no copy of it in the library of the Royal Society, nor in that of the Royal College of Physicians. Copies are to be found in the libraries of the University of London, University College, and of the Royal Society of Medicine. That the 'Exposition' &c. of 1824 was regarded by Bell as the first edition of his 'Nervous System' is established by a footnote on p. 14 of the 'Nervous System' of 1830. The editions of 1836 and 1844 are both entitled 'Third Edition.' The sequence is thus:—

I. 1824 [First Edition]—'An Exposition of a Natural System of Nerves of the Human Body.
II. 1830 [Second Edition]—'The Nervous System of the Human Body.'
III. 1836 and 1844 Third Edition—'The Nervous System of the Human Body.'

made upon living animals; not under the direction of anatomical knowledge or the guidance of just induction, but conducted with cruelty and indifference, in hope to catch at some of the accidental facts of a system which, it is evident, the experimenters did not fully comprehend.'

On the last page (p. 66) of the introduction Bell says:—

'I will now lay before my readers the papers which I presented to the Royal Society on this subject, and in the order they are printed in the "Philosophical Transactions."'

The remainder of the volume from p. 67 to p. 392 consists of the four papers published from 1821 to 1823, to which we have already alluded. At first sight these are simple republications: each of the four papers is headed by the words, *from the 'Philosophical Transactions,'* 1821, 1822, and 1823. Read before the Royal Society July 12, 1821, May 2, 1822, March 20, 1823, June 19, 1823.

But when we come to compare these 'republished' with the original papers we find that they contain emendations, quite insignificant as to bulk, but most significant as to meaning. For they occur at crucial passages and have the effect of transforming erroneous statements in the original version into correct statements in the revised version. And we search the volume in vain from cover to cover for some indication by Bell that the text of the republished papers contains alterations. And when we look more closely into the differences of text we find that their collective effect has been completely to transform the original meaning of Bell's principal statements not only as regards points of interpretation but also as regards descriptions of experiment.[3]

The slight emendations silently made in this first edition of 1824 are transferred to and amplified in subsequent editions. In the third edition, which in one or other of its two issues of 1836 and 1844 is the ordinary and regular source of information concerning Bell's work, the transformation of statements is complete, and in this third edition at the foot of p. 33, p. 48, and p. 89 we find an acknowledgment by Bell that the republished are not identical with the original texts. But in 1836 there can be no particular objection to the editing of the text. The mischief had been done in 1824 by the unacknowledged alterations.

I shall quote a single paragraph from the original paper of 1821 and from the republished paper of 1824 in illustration of the subtle character of Bell's emendations of text in 1824 while at the height of his campaign against Magendie:—

ORIGINAL VERSION, 'PHIL. TRANS.,' 1821, pp. 409-410.

Of the Trigeminus or Fifth Pair.

'In all animals that have a stomach, with palpi or tentacula to embrace their food, the rudiments of this nerve may be perceived; and always in the *vermes*, that part of their nervous system is most easily discerned which surrounds the œsophagus near the mouth. If a feeler of any kind project from the head of an animal, be it the antenna of the lobster or the trunk of an elephant, it is a branch of this nerve which supplies sensibility *and animates its muscles*. But

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[3] **See the account of the experiment of the 'thrown ass' in the *Philosophical Transactions* of 1821, and in Bell's three editions, viz., in 1821 at pp. 412-3; in 1824 at pp. 105-7; in 1830 at pp. 73-4; 1836 and 1844, at pp. 52-3.**

this is only if it be a simple organ of feeling, and is not in its office connected with respiration.

'From the nerve that comes off from the anterior ganglion of the leech, and which supplies its mouth, we may trace up through the gradations of animals a nerve of taste and manducation until we arrive at the complete distribution of the fifth or trigeminus in man (see Plate XXX., B.C.D., which are its three grand divisions to the face). Here in the highest link, as in the lowest, the nerve is subservient to the same functions. It is the nerve of taste, and of the salivary glands, of the muscles of the *face and* jaws, and of common sensibility. This nerve comes off from the base of the brain in so peculiar a situation that it alone of all the nerves of the head receives roots both from the medullary process of the cerebrum and of the cerebellum. A ganglion is formed upon it near its origin, though some of its filaments pass on without entering into the ganglion. Before passing out of the skull the nerve splits into three great divisions, which are sent to the face, jaws, and tongue. Its branches go minutely into the skin and enter into all the muscles, and they are especially profuse to the *muscles which move the* lips *upon the teeth*.

REVISED VERSION. REPRINT OF 1824, pp. 95–6.

Of the Trigeminus or Fifth Pair.

'In all animals that have a stomach, with palpi or tentacula to embrace their food, the rudiments of this nerve may be perceived; and always in the *vermes*, that part of their nervous system is most easily discerned which surrounds the œsophagus near the mouth. If a feeler of any kind project from the head of an animal, be it the antenna of the lobster or the trunk of an elephant, it is a branch of this nerve which supplies sensibility. But this is only if it be a simple organ of feeling, and is not in its office connected with respiration.

'From the nerve that comes off the anterior ganglion of the leech, and which supplies its mouth, we may trace up through the gradations of animals a nerve of taste and manducation until we arrive at the complete distribution of the fifth or trigeminus in man (see Plate III., in which there are its three grand divisions of the face). Here in the highest link, as in the lowest, the nerve is subservient to the same functions. It is the nerve of taste, and of the salivary glands; of the muscles of the jaws, and of common sensibility. This nerve comes off from the base of the brain in so peculiar a situation that it alone of all the nerves of the head receives roots both from the medullary process of the cerebrum and of the cerebellum. A ganglion is formed upon it near its origin, though some of its filaments pass on without entering into the ganglion. Before passing out of the skull, the nerve splits into three great divisions, which are sent to the face, jaws, and tongue. Its branches go minutely into the skin, and enter into all the muscles, and they are especially profuse to the lips.'

The differences between the two passages are very small but very important; they are three in number:—

At line 6 the words '*and animales its muscles*' are deleted.

At line 15 the words '*face and*' are deleted.

At the last line '*to the muscles which move the lips upon the teeth*' is replaced by the words '*to the lips*.'

The net result of these three emendations is that the fifth nerve (*i.e.*, its portio major) which is motor and sensory in Bell's original paper of 1821 is sensory only in his republication of 1824.

In the third edition of Bell's 'Nervous System' (1836 and 1844) at p. 48 the passage is substantially as in the revised version of 1824, the only difference being that now the words '*from the column of sensibility and from that of motion*' are substituted for the words '*from the medullary process of the cerebrum and cerebellum*' used in the versions of 1821 and of 1824.

But the revised passage now has below it the following footnote which, while hardly of an explanatory nature, shows that the alteration had not been regarded as insignificant either by Bell or by his critics:—

> 'The reader is referred to the next paper (on the facial nerves—"Phil. Trans.," 1829) and the explanation of the plates for the more minute anatomy of this nerve. I have often been requested in vindication of the correctness of my original account of the fifth nerve to report my early statement of the uses of this nerve. I can give nothing more distinct than in this passage, and I suspect that mistakes on this point have been encouraged and propagated in consequence of the limited circulation of this work in its first expensive shape of publication.'

On p. 5 of the preface to this edition Bell says:—

> 'Eight papers were in succession printed in the Royal Society's "Transactions." It would be a great labour to recast the whole of these so as to present them in a strictly systematical form; and, if not misled by the partiality of friends, the author believes that the observations will be more acceptable in their original form.'

Bell's Figures of the Fifth Nerve in 1821 *and* 1824.—The figure and its explanation are altered in 1824 to correspond to the altered text. In 1821, p. 423, as regards the three divisions of the fifth the explanation of Plate XXX. is as follows:—

> B.—The frontal division of the *trigeminus* or fifth nerve.
>
> C.—The infra-orbital division of the same fifth nerve. This branch is large and its sub-divisions form a plexus before finally dividing to supply the muscles of the nostril and lip.
>
> D.—The third grand division of the fifth nerve, or mandibulo-labialis, to the muscles and integuments of the chin and lower lip.

In 1824, at p. 143, the original plate is replaced by a simplified diagram, Plate III., and the explanation is amplified by the following paragraph:—

> 'In this plate the two distinct classes of nerves which go to the face are represented, the one to bestow sensibility, and the other for motion, and particularly for the motions of speaking and expression—that is, the motions connected with the respiratory organs.
>
> 'The nerves on the side of the neck are also represented. These I have discovered to be double nerves, performing two functions; they control the muscular frame and bestow sensibility on the skin. . . .'

This paragraph, added in 1824 without acknowledgment to the republished paper of 1821, constitutes the first explicit statement published by Bell of a distinction between motor and sensory nerves.

It passes on without acknowledgment into the subsequent editions of 1830 (Plate VI., clxiii.), and of 1836, 1844 (Plate VI., p. 464).

In 1824 the explanation of the plate as regards the fifth nerve is as follows:—

> I.—Frontal nerve, a branch of the fifth.
> II.—Superior maxillary nerve, a branch of the fifth.
> III.—Mandibulo-labialis, a branch of the fifth.
> V.—Temporal branches of the second division of the fifth.

V. Conclusion.—In conclusion I submit that Bell's claim to the discovery of the distinction between motor and sensory nerves in so far as it depends upon data relating to the fifth and seventh is (1) not proved by his publications of 1821-22, and (2) discredited by the unacknowledged emendations of the text of 1821 in the republished papers of 1824. In so far as his claim depends upon data relating to the spinal roots it is not proved by his privately printed pamphlet of 1811. Magendie alone is entitled to the honour of the discovery.

The Bell-Magendie issue stands altogether outside and above the ordinary category of priority disputes. The discovery is of an importance that forbids its wrongful attribution either to Bell or to Magendie; and if the honour belongs exclusively to either man, it should not be wrongfully divided between both men.

For nearly a century it has been customary to attribute the discovery exclusively to Bell. Of recent years it has occasionally been attributed to Bell and Magendie conjointly—to Bell as the pioneer, and to Magendie as the follower. Either of these conclusions is, I submit, unjust to Magendie. The plea of patriotism, first invoked by Bell in 1823, and adopted by his partisans in 1833 and 1839 and 1911, is not admissible in a purely scientific issue.

Yet since that plea has been invoked, and if, as I believe, justice is due to Magendie, it is permissible to hope for the sake of our own self-respect that justice may be rendered to him in our own language.

It is assuredly right and proper that the British Association for the Advancement of Science, which in 1833 received the statement that 'the honour of the discovery belongs exclusively to Sir Charles Bell,' should, even after many years, be invited to examine the foundations of that statement when it has been seriously called in question. The published documents, ignored in 1833, are still in existence.

VI. APPENDIX.

1. *Magendie's Reply to Bell.*—Magendie's first and immediate reply to the reclamation of priority made in 1822 by John Shaw on behalf of Bell was to print it in full in his 'Journal de Physiologie' (Vol. II., p. 370). At that time he believed that the allusion to an experiment by Bell in the 'Idea' of 1811 referred to a physiological experiment made on a living animal, as is evident by his quotation of the passage containing the allusion. His reply, on p. 371, is as follows:—

> **'On voit par cette citation d'un ouvrage que je ne pouvois connaître puisqu'il n'a point été publié, que M. Bell, conduit par ses ingénieuses idées sur le système nerveux, a été bien près de découvrir les fonctions des racines spinales; toutefois le fait que les antérieures sont destinées au mouvement, tandis que les postérieures appartiennent plus particulièrement au sentiment, paraît lui avoir échappé; c'est donc à avoir établi ce fait d'une manière positive que je dois borner mes prétentions.'**

Magendie's second reply subsequent to Bell's comments upon the cruel and useless experiments of French physiologists (p. 6) is given

in the prefatory footnote to the translation of Bell's last paper on the 'Nerves of the Face,' of 1829, printed in the tenth volume of the 'Journal de Physiologie,' 1830, p. 1, and is as follows:—

> 'Je me suis toujours fait un devoir de présenter aux lecteurs de ce Journal les travaux anatomiques de M. Ch. Bell. Son esprit investigateur bien qu'un peu spéculatif, sa grande habileté dans l'art de disséquer, et son rare talent pour le dessin, lui assureront toujours une place distinguée parmi les anatomistes de notre époque. Pourquoi faut-il que ce savant nuise à ses travaux, se nuise à lui-même en ne rendant pas à ses émules la justice qui leur est due? Pourquoi conserve-t-il ce patriotisme barbare qui repousse tout ce qui n'est pas du pays? Pourquoi garde-t-il des prétentions à des découvertes qu'il n'a pas faites? Sans doute parce que tel est son caractère, et qu'il n'est pas facile de se changer, quand même on en sentirait le désir. D'ailleurs ce travers, que notre franchise se permet de blâmer en lui, est peut-être le mobile qui l'excite au travail, et alors voudrions-nous réellement qu'il ne l'eût pas?'

2. *Bell's Valedictory Letter of* 1830.—Bell's estimate of his own qualifications as a physiologist is most clearly conveyed in his valedictory address of November 25, 1830, on resigning the chair of physiology of the University of London, and printed under the title: Mr. Bell's Letter to his Pupils of the London University, on Taking Leave of Them:—

> 'I had my lesser and personal grievances. To those who know how little I value physiology, in the common acceptation of the term, it will be a proof of my desire to see the experiment of a new school fairly tried that I submitted to be called professor of a science (if science it be) on which an inceptor candidate for medical degrees would read lectures more readily than I could. You are aware that the subjects on which I lectured were the higher departments of anatomy— that I reasoned on a demonstration in which my knowledge of anatomy and my experience of disease came into use as laying the foundation of just principles in the practice of your profession. If you will call to recollection any one lecture, or take the last of all as an instance, you will see how little the subject-matter of my lecture corresponds with the title put upon them.
>
> 'It has been imputed to me as a fault that I wished to preside over the anatomical department. I avow this; and I entered the University on that understanding. But this on my part was no assumption of superiority, beyond what time, study, and experience give to every man.'

TRANSACTIONS OF THE SECTIONS.

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SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

PRESIDENT OF THE SECTION.—PROFESSOR H. H. TURNER, D.Sc., D.C.L., F.R.S.

THURSDAY, AUGUST 31.

The President delivered the following Address :—

The Characteristics of the Observational Sciences.

IT will doubtless startle my audience to hear that this Section has only once in its history been addressed by an astronomical President upon an astronomical topic. I hasten to admit that I am not using the term astronomical in its widest sense. Huxley once declared that there were only two sciences, Astronomy and Biology, and it is recorded that 'the company' (which happened to be that of the Royal Astronomical Society Club) 'agreed with him.' One may agree with the company in assenting to the proposition in the sense in which it is obviously intended without losing the right to use the name astronomy in a more restricted sense when necessary; and at present I use it in its classical sense. At Brighton, in 1872, Dr. De La Rue addressed Section A on Astronomical Photography in words which are still worthy of attention, though they are all but forty years old; and this is the only instance I can find in the annals of the Section. There have, of course, been occasional astronomical Presidents such as Airy, Lord Rosse, and Dr. Robinson, but these presided in early days before the Address existed, or when it was brief and formal; and the only allusions to astronomical matters were the statements, by Robinson and Airy, of what the Association had done in subsidising the reduction of Lalande's observations and the Greenwich lunar observations. In 1887 Sir Robert Ball occupied this chair, but he selected from his ample scientific wardrobe the costume of a geometer, and left his astronomical dress at home. A great man whose death was announced almost as I was writing these words, Dr. Johnstone Stoney, spoke (in 1879 at Sheffield) of the valuable training afforded by the study of mechanics and of chemistry, with that keen insight which made him so valuable a member of our Section. Other Presidents whom we have been glad to welcome as astronomers at certain times and seasons did not choose the occasion of their presidency for any very definite manifestation of astronomical sympathy.

The Addresses of Sir George Darwin (in 1886) and of Professor Love (in 1907) on the past history of our earth certainly have an astronomical bearing, but if we distinguish between the classical astronomy and its modern expansions they would be assigned to the latter rather than to the former; and so do the few astronomical allusions in Professor Schuster's Address at Edinburgh in 1892. Even if we include, instead of excluding, all doubtful cases, there will still appear a curious neglect of astronomy by Section A in the last half-century, all the more curious when it is remarked that the neglect does not extend to the

Association itself, seeing that there have been three Astronomical Presidents of the Association who had not been previously chosen to fill this chair. The neglect is not confined to astronomy but extends, as some of us recently pointed out, to the other sciences of observation; and we thought that, as a corollary, it would be better for the Section to divide, in order that these sciences might not continue the struggle for existence in an atmosphere to which they were apparently ill-suited. But the Section decided against the suggestion, and I have no intention of appealing against the decision. This explicit statement will, I trust, suffice to prevent misunderstanding if I proceed to examine the possible causes of neglect—for I cannot but regard the record as significant of some cause which it will be well to recognise even if we cannot remove it. Personally I think the cause is not far to seek, and my hope is to make it manifest; but as the statement of it involves something in the nature of an accusation, I will beg leave to make it as gently as possible by using the words of others, especially of those against whom the mild accusation is to be made.

Let me begin by quoting from the admirable Address—none the less admirable because it was only one-quarter of the length to which we have become accustomed—delivered by my late Oxford colleague, the Rev. Bartholomew Price, at Oxford in 1860, wherein he referred to the constitution of this Section as follows :—

> The area of scientific research which this Section covers is very large, larger perhaps than that of any other; and its subjects vary so much that while to some of those who frequent this room certain papers may appear dull, yet to others they will be full of interest. Some of them possess, probably in the highest degree attainable by the human intellect, the characteristics of perfect and necessary science; while others are at present little more than a conglomeration of observations, made indeed with infinite skill and perseverance, and of the greatest value: capable probably in time of greater perfection, nay, perhaps of the most perfect forms, but as yet in their infancy, scarcely indicating the process by which that maturity will be arrived at and containing hardly the barest outline of their ultimate laws.

A little later in the Address Professor Price made it quite clear which were the sciences 'in their infancy' :—

> And finally we come to the facts of meteorology and its kindred subjects, many of which are scarcely yet brought within any law at all.

There is here much that will command ready and universal assent; but is there not also a rather unnecessary social scale? The science of planetary movement had not yet been 'brought within any law at all' (as we now use the term) in Tycho Brahé's time; but was the astronomy of Tycho Brahé socially inferior to that of Kepler? It is difficult to fix the eye on such a question without its being caught by the splendour of Newton towering so near; and the idea of a scale descending from that great height is almost irresistibly suggested. But in spite of this grave difficulty, I ask whether there is of necessity any drop whatever from the plane of Kepler, who realised the laws, to that of Tycho, who never reached any suspicion of the true laws, but had nevertheless such faith in their existence that he cheerfully devoted his life to labours of which he never reaped the fruits? Is it not a dangerous doctrine that the work done previous to the formulation of a law is in any way inferior? Take the case of a man like Stephen Groombridge, who made thousands of accurate observations of stars in the early part of last century. Fifty years later something of the value of his work began to emerge from a comparison with later observations which showed what stars had moved and how; but it was not until nearly a century had elapsed that something about the laws of stellar movement was extracted from his patient work, combined with a repetition of similar works at Greenwich. *Then*, with the skilful assistance of Mr. Dyson and Mr. Eddington, Groombridge at last came into the fruits of his labours; but had he been asked during his lifetime for credentials in the shape of laws, on pain of being classed as an inferior in the social scientific scale, he would have been lamentably unprepared. Or consider the case of M. Teisserenc de Bort, when he began sending up his balloons. 'Show me your laws,' cries the mathematician. 'But they are just

what I hope to find,' replies M. de Bort. 'Yes, but surely you have formulated some law you wish to test?' pursues the invigilator. 'How am I to give you proper scientific rank unless you can produce at least a tentative law?' 'On the other hand I wish to keep a perfectly open mind,' maintains M. de Bort. 'Then I fear I cannot admit you to our class at present; you must join the infants' class, and I can only give you my best wishes that you may reach maturity some day.' Unperturbed, M. de Bort continues to send up his balloons, and almost immediately discovers the great fact about the isothermal region which will be a permanent factor in the meteorology of the future. The mathematician is now ready to admit him, as a worthy person who has found a law about the constitution of the atmosphere. But was not the merit in sending up the balloons whatever came of it? Is it not sometimes more courageous to take risks of failure? The mathematician, safe in his stronghold which possesses 'probably in the highest degree attainable by the human intellect the characteristics of perfect and necessary science' is like a man who has inherited a good old-established business, and he has a distaste for the methods of those who have to try new ventures. No doubt many who make such trials fail; but, on the other hand, great fortunes have been made in that way.

It may seem, however, that too much is being deduced from a single quoted opinion, which may easily have been personal and not representative. Let me, therefore, take another which presents a different aspect of the same matter. I take the opening words of Sir George Darwin's Address to this Section at Birmingham in 1886:—

> A mere catalogue of facts, however well arranged, has never led to any important scientific generalisation. For in any subjects the facts are so numerous and many-sided that they only lead us to a conclusion when they are marshalled by the light of some leading idea. A theory is then a necessity for the advance of science, and we may regard it as the branch of a living tree, of which facts are the nourishment.

Those who have read the letters of Charles Darwin[1] will recognise that this opinion was also held by the father, and may have been adopted by the son. It is no part of my purpose to raise any question of originality: I mention the point merely to take the opportunity it gives me of showing that I do not approach lightly an opinion held by two such men. With the utmost respect I wish to question whether the criterion indicated goes deep enough. Often have we had ocular demonstration of the value of a theory in stimulating the advance of science, but is advance wholly dependent on the existence of a theory? I have tried to indicate already a deeper motive power by such instances as the work of Tycho, who had no theory, but who perceived the need of observation. And I will now definitely formulate the view that the perception of the need for observations, the faith that something will come of them, and the skill and energy to act on that faith—that those qualities, all of which are possessed by any observer worthy the name, have at least as much to do with the advance of Science as the formulation of a theory, even of a correct theory. The work of the observer is often forgotten—it lies at the root of the plant; it is easier to notice the theories which blossom and ultimately produce the fruit. But without the patient work of the observer underground there would be neither blossom nor fruit. It is also easy to fix attention on the mechanical nature of much observation; but this is not the principal feature of observing any more than is numerical computation of mathematics. There are men like Adams who perform gigantic numerical computations faultlessly, but there are others who would take equal rank as mathematicians who cannot do three additions correctly; and again others who could compute well and quickly but prefer to hand over that part of their work to someone else. Similarly some great observers themselves look through the telescope, and some merely direct others how to do so; the spark of divine fire is not

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[1] Since the Address was delivered and reports of it appeared in the press, two correspondents have independently called attention to the fact that Charles Darwin's attitude is not correctly represented, quoting his own words, 'I worked on true Baconian principles and without any theory collected facts on a wholesale scale' (*Life*, i., 83). I wish to acknowledge the correction wholeheartedly.—H. H. T.

dependent on this detail, but on the possession of the qualities above mentioned—perception, faith, skill, and energy.

By way of bringing out more fully the nature of the assertion made by Sir George Darwin, let me beg your attention to a striking incident in recent astronomical history. We all know how the great astronomer we lost last year, Sir William Huggins (one of those already mentioned as having occupied the presidential chair of the Association without having filled that of Section A), initiated the determination of velocities of the heavenly bodies in the line of sight by means of the spectroscope. We know further how the accuracy of these determinations was improved by the application of photography, so that it has recently become possible to measure the velocity of the earth in its orbit (as it alternately approaches and recedes from a given star) with a precision which matches that of other known methods. Now Mr. W. W. Campbell, on his appointment as Director of the Lick Observatory in 1900, perceived the desirability of observing the line of sight velocities of as many stars as possible, believed that that outcome would be in some way for the advancement of science, and resolutely acted on that belief, so that for many years the resources of his great establishment have been devoted to this work. He has not turned aside from it even to publish provisional results, and has thereby incurred some adverse criticism. But, having now accumulated a large mass of observation, he is proceeding to let them tell their own tale, and a wonderful story it is. We have unfortunately not time to listen to more than a fraction of it at the moment; but that fraction is well worthy of our attention. When the stars are grouped in classes according to their spectral type, their average velocities differ; and if the spectral types are arranged in that particular order which for quite independent reasons we believe to be that of development of the stars, there is a steady increase in the velocities. To put the matter in a nutshell, the older a star is the quicker it moves. There are no doubt several assumptions made in reducing the matter to this simple statement, but I venture to think that they do not affect the point I now wish to make, which is as follows. There is no doubt whatever that the catalogue of facts accumulated by Mr. Campbell, when arranged in an obvious order, has led to a most important scientific generalisation—a direct negative at this date of Sir George Darwin's opening sentence, however true it may have been when he wrote it. If we read on, his next sentence doubtless entitles him to say that it was the marshalling of the facts which led to the conclusion. It is not altogether clear to me in what way this marshalling differs from the permitted 'arrangement' of the catalogue; but the third sentence seems to imply that the distinction lies in the existence of a theory. But certainly Mr. Campbell had no theory; so far is he from having had a theory that he finds it extremely difficult, if not at present actually impossible, to formulate one, which will satisfactorily account for the extraordinary fact brought to light by the simple arrangement of his catalogue.

Witness his words in Lick Observatory 'Bulletin,' No. 196, dated April 20 last :—

> The correct interpretation of the observed facts referred to in this 'Bulletin' seems not easy of accomplishment, and the brief comments which follow make no pretensions to the status of a solution.
>
> That stellar velocities should be functions of spectral types is one of the surprising results of recent studies in stellar motions, for we naturally think of all matter as equally old gravitationally. Why should not the materials composing a nebula or a Class B star have been acted upon as long and as effectively as the materials in a Class M star? . . . The established fact of increasing stellar velocities with increasing ages suggest the questions : Are stellar materials in the ante-stellar state subject to Newton's law of gravitation? Do these materials exist in forms so finely divided that repulsion under radiation pressure more or less closely balances gravitational attraction? Does gravity become effective only after the processes of combination are well under way?

Mr. Campbell is far from being helpless in the situation he has created; he is ready with suggestions, though he modestly puts them as questions; but they are obviously consequent, and not antecedent, to the advance which he has made.

Even if the like has never happened before, *this* scientific advance is at any rate due to little more than the accumulation of facts which arranged themselves, as Bacon hoped would naturally happen. But does it detract from the merits of this fine piece of observational work that it was suggested by no leading theory? And I will ask even further: Would its merits have been less if no such immediate induction had presented itself? To this second question I can scarcely expect a general answer in the affirmative; it is so natural to judge by results, and so difficult to look beyond them to the merits of the work itself that I shall not easily carry others with me in claiming that the merits of the observer shall be assessed independently of his results. And yet I affirm unhesitatingly that until this attitude is reached, we cannot do justice to the observer. I believe it will be reached in the future, and I shall endeavour to give reasons for this forecast; but I admit frankly that our habit of judging by results will be hard to break. It extends even to the observer himself, and leads to the withholding of his observations from publication, so that he may himself extract the results from them. In the pure interests of the advance of knowledge, it would be far better to publish the material, so that many brains rather than one might work upon it. But the observer knows that by this course he risks losing almost the whole value of his patient work, which would pass as unearned increment to the particular person who was lucky enough to make the induction. Hence arise quarrels such as those between Flamsteed and Newton; the former refusing to publish his observations until he had himself had an opportunity of discussing them, while Newton and Halley exerted their powerful influence in the contrary sense. This situation by no means belongs to a bygone age; it may and does arise to-day, and will continue to arise so long as the recognition of the observer's work is inadequate. It was mentioned a few minutes ago that Mr. Campbell had incurred adverse criticism by accumulating a considerable mass of unpublished observations. Let me be careful not to suggest that his primary motive was the desire to have the first use of them, for I happen to know that there was at least one other good and sufficient reason for his action in the difficulty of finding funds for publication, a difficulty with which observers are only too familiar. But, whatever the reason, there were those who regretted the delay in publication as hindering the advance of science. The whole question is a delicate one, and might have been better left unraised at the moment but for a most curious sequel, which puts clearly in evidence the importance of the observer and the desirability of allowing him to discuss his own work. To make this clear a small digression is necessary.

During the last half-dozen years astronomers have been startled on several occasions by pieces of news of a particular kind, indicating the association of large, widely scattered groups of stars in a common movement. The discussion of these movements is to occupy the special attention of this Section at one of our meetings, which is an additional reason for brevity in the present allusion. Possibly also most members of the Section have already heard of Professor Kapteyn's division of the great mass of bright stars into two distinct groups flying one through the other; and again of the discovery by Professor Boss of a special cluster of stars in the constellation Taurus, moving in parallel lines like a flock of migrating birds. The fascination of this latter discovery, and of one or two others like it, is that when the information supplied by the spectroscope is combined with that furnished by the long watching of patient observers, we can determine the distance of the cluster and its shape and dimensions. We realise, for instance, that there is a large flat cluster migrating just over our heads, so that one member of it (Sirius) is close to our Sun—that is to say, only nine or ten light-years from him. 'Close' is a relative term; and the distance travelled by light in three years is from some standpoints by no means despicable. But it is small in comparison with the dimensions of the cluster, which is about one hundred light-years from end to end. The study of these clusters will doubtless occupy our close attention in the immediate future; and it is very natural that the discovery of one should lead to the search for others. Accordingly we heard last autumn with the deepest interest, but with modified surprise, the announcement of common movement in a class of stars of a particular spectral type. The announcement rested to some extent on the work done at the Lick Observatory, much of which has been published in an abbreviated

form. But Mr. Campbell, in the Lick Observatory 'Bulletin' already quoted, gives reasons why he cannot accept the conclusion, which is vitiated, in his opinion, by the existence of a systematic error in the observations. Now on such a point as this the observer himself is at any rate entitled to a hearing, and is often the best judge. To take proper precautions against systematic errors is the business of the observer, and his efficiency may very well be estimated by his success in this direction—this would be a far safer guide than to judge by results. But sometimes such errors, which are very elusive, do not suggest themselves until the observations have been completed, and must be detected from the observations themselves. This, again, is rightly the business of the observer, and the desire to free his observations from such error is a perfectly sound and scientific reason for withholding publication. In the present instance the error is a peculiarly insidious one; and, indeed, we are not even certain that it is an error. It is a possible alternative interpretaton of the facts that the stars with Class B spectrum are in general moving outwards from the Sun, and the additional fact that there is a comparatively large volume of space round the Sun at present empty of B stars would seem to favour this alternative. But, as already mentioned, the observer himself prefers rather to credit his observations with systematic error which gives a spurious velocity of 5 km. per second to stars of this type. Now it will readily be understood how an error of this kind may appear doubled: two vehicles travelling in opposite directions approach or recede from each other with double the speed of either; and if one were erroneously supposed to be at rest, the other would be judged to travel twice as fast. In this way the B stars in a particular portion of the sky were judged to be travelling with a common motion of 10 km. per second, which would have been a discoverey of far-reaching importance if true, but which the observer relegates to the category of systematic errors.

The illustration will suffice to remind us that the work of the observer is far from being merely mechanical: it demands also skill and judgment—skill in defeating systematic error, and a fine judgment, born of experience, of the success attained. All this is independent of the generalisations which may or may not be arrived at. Bradley's skill as an observer enabled him to discover the Aberration of Light and the Nutation of the Earth's Axis; it was enhanced rather than lessened when he went on to make further observations which, had he lived, would have conducted him to the discovery of the Variation of Latitude. After his death the world waited more than a century for this discovery to be made, but Mr. Chandler, who played a leading part in it, has declared that Bradley was almost certainly on its track. It would almost seem that an observer is only properly appreciated by another observer. There are doubtless many who, assisted by the knowledge that Bradley's skill had twice previously conducted him to a discovery, would be ready to admit the value of his later work, although he did not live to crown it; but how many of those could properly appreciate Bradley without such assistance?

I venture to think that the great brilliance of Newton has dazzled our vision so that we do not see some things quite clearly.

> Had it not been for Newton [writes De Morgan in his 'Budget of Paradoxes,' p. 56] the whole dynasty of Greenwich astronomers, from Flamsteed of happy memory, to Airy, whom Heaven preserve, might have worked away at nightly observation and daily reduction without any remarkable result: looking forward, as to a millennium, to the time when any man of moderate intelligence was to see the whole explanation. What are large collections of facts for? To make theories *from*, says Bacon; to try ready-made theories *by*, says the history of discovery; it's all the same, says the idolater; nonsense, say we!

But nothing of this will fit in with what we know of Bradley's work; he discovered aberration, not by any help from Newton, but by accumulating a mass of observations. He had no ready-made hypothesis, or rather he had a wrong one, viz., that the stars would show displacement due to parallax: and after this was proved wrong, as it was at the very outset, he had nothing in the way of a theory to guide him, and found great difficulty in devising one

after he had collected his facts, which spoke for themselves so far as to reveal plainly the essential features of the phenomenon in question.

> Modern discoveries (on the preceding page of the 'B. of P.') have not been made by large collections of facts, with subsequent discussion, separation, and resulting deduction of a truth thus rendered perceptible.

To this I venture to oppose not only such work as that of Bradley, but much in the recent history of astronomy; the discoveries about systematic proper motions, about moving clusters, about the growth of velocity with life history, and so forth.

> There is an attempt at induction going on, which has yielded little or no fruit, the observations made in the meteorological observatories. The attempt is carried on in a manner which would have caused Bacon to dance for joy. . . . And what has come of it? Nothing, says M. Biot, and nothing will ever come of it: the veteran mathematician and experimental philosopher declares, as does Mr. Ellis, that no single branch of science has ever been fruitfully explored in this way.

De Morgan was a mathematician, and I have noticed that mathematicians are apt to be crisp in their statements: but he is a bold man who says 'nothing will ever come of it.' Perhaps an equally crisp statement on the other side may be pardoned. I adventure the remark that if nothing has hitherto come of such observations, it is because observers have been misled by the very teaching of De Morgan and others who share his views: they have been told that they will do no good without a theory until they have come to believe it: whereas the truth probably lies in a quite different direction. To present my reasons for this proposition I must ask you first to consider in some detail the method of discussing meteorological observations suggested some years ago by Professor Schuster. He gave an account of it to the Department of Cosmical Physics over which he presided in 1902, so that I must face some repetition of what he said; but the matter is so important that I trust this may be pardoned.

Let us compare the records produced on a gramophone disc by the playing of a single instrument and by that of an orchestra. The first will be comparatively simple, and when suitably magnified will show a series of waves which in certain parts of the record form sequences of great regularity. These represent occasions when the single instrument played a long sustained note, the pitch of which is indicated by the frequency of the wave. If the instrument plays more loudly, while still keeping to the same note, the heights of the waves will increase, though their frequency will not be altered. The exact shape of each wave will represent the quality of tone which characterises the instrument: and if another instrument were to play the same note it would be different. But so long as we keep to the same instrument, whenever the same note recurred we should find, generally speaking, the same shape of wave: and we could resolve it into its constituents, one being the main wave and others harmonics of different intensities. The analysis of such a record would thus be a comparatively simple matter, on which we need scarcely dwell further. Very different is the case of the orchestral record. There are numerous instruments, playing notes of different pitch, intensity, and character, each of which, if playing alone, would produce its own peculiar record. But when they play together the records are all combined into one. The needle can only make one record, but it is a true sum of all the individuals; for when the instrument is set to reproduce the playing of the orchestra, a trained ear can perceive the playing of the separate instruments—when the strings are playing alone, and when the wind joins them: when the horn comes in and whether there are two players or only one: nay, even that one of the second violins is playing somewhat flat! This could not happen unless the individual performances were essentially and truly existent in the combined record; and yet this consists of only one single wavy line. The waves are, however, now of great complexity, and it seems at first sight hopeless to analyse them. The mathematician knows, however, that such analysis is possible, and is quite simple in conception, though it may be laborious in execution. Selecting a note of any given pitch, a simple calculation devised by Fourier will reveal when and how loudly that particular note was being

played. This being so, it is only necessary to repeat the process for notes of different pitch. But though this can be stated so simply, the carrying out in practice may involve immense labour, by reason of the number of separate notes to be investigated. It is not merely that these will extend from low growls by the double bass to high squeaks by the fiddles, but that their variety within these wide limits will be so great. The series is really infinite. We might indeed prescribe a certain scale of finite intervals for the main notes, as in a piano: but the harmonics of the main tones would refuse to obey this artificial arrangement and would form intermediate pitches which must be properly investigated if our analysis is to be complete. Moreover the orchestral instruments will not keep to any such prescribed intervals, but will insist on departing from them more or less, according to the skill of the performer. There is a story told of an accompanist who vainly tried to adjust the key of his accompaniment to the erratic voice of a singer. At length in exasperation he addressed him as follows: 'Sir, I have tried you on the white notes, and I have tried you on the black notes, and I have tried you on white and black mixed: you are singing on the cracks!' Some instruments will almost certainly 'sing on the cracks' so that we shall not easily escape from the examination of a very large number of possibilities indeed--we may well call them *all* the possibilities within the limits of audibility. The illustration is already sufficiently developed for provisional use. My suggestion is that science has only dealt so far with the easy records and that the genuine hard work is to come. If we can imagine a number of deaf persons turned loose among a miscellaneous collection of gramophone records, with instructions to make what they could of them, we can readily imagine that they would pick out those of single instruments first. We must make the researchers deaf so that they may not use the beautiful mechanism of the human ear which has as yet no analogue in scientific work. Possibly something corresponding to this wonderful and still mysterious mechanism may ultimately be devised, and then the course of scientific research may be fundamentally altered: but for the present we must regard ourselves as deaf, and as condemned to work by patient analysis of the records. It is perfectly natural, and even desirable, to begin with the easy ones, and the finding of an easy one would no doubt in our hypothetical case be a sensational event, reflecting credit on the lucky discoverer, who would be hailed as having detected a new law, *i.e.*, a new simple case. But sooner or later these will be used up and we must attack the more complex orchestral records in earnest. Shall we find that the best music is still to come, as our illustration suggests?

But we must return to Professor Schuster's suggested plan of work. It is closely similar to that already sketched for dealing with a complex gramophone record. Let us consider the record of any meteorological element such as temperature or rainfall. When these records are put in the form of a diagram in the familiar way we get a wavy line, which has much in common with that traced by a gramophone needle on a smaller scale. The sight of the complexities is almost paralysing, especially when those who would otherwise attack the problem are deterred by the emphatic assertion that it is useless to do so without the equipment of some guiding hypothesis. Most of the obvious hypotheses have of course already been tried, and the majority of them have failed. It is to Professor Schuster that we owe the vitally important advice to disregard hypotheses and make a complete analysis of the record. Of course the labour is great, but the genuine observer is not afraid of labour: he has a right to ask of course that it shall not be interminable: and when we are told that we must examine an almost infinite series of possibilities there would seem to be some danger of this. But in practice the work always resolves itself into a series of finite steps, owing to the finite extent of the observations. A definite illustration will make this clear. Suppose we have ninety years of rainfall and we test the record for a frequency of nine years, which would run through its period ten times: we must certainly test independently for a frequency of ten years, which would only run through its period nine times, and thus lose one whole period on the former wave: and so also for a possible frequency of nine years and a half, and of nine years and a quarter. But a frequency of nine years and one day would not be distinguishable from that of nine years, for the phase would only change 1° in the whole available period of observation. Indeed

the same might be said of all frequencies between nine years and nine years and one month: for the extreme difference of phase would not exceed 40°. But in course of time when the series of ninety years' observations become 900 years, the differences of phase will approach or exceed a complete cycle, and we must accordingly narrow the intervals between frequencies chosen for examination.

The length of the series of observations is thus an important factor in our procedure, for which Professor Schuster has indicated a beautiful analogy. Our illustrations hitherto have been provided by the science of sound, but we may also gather them from that of optics. Testing a series of rainfall observations for a periodicity is like examining a source of light for a definite bright line. The process of computation indicated by Fourier gives us what corresponds to the measured brilliance of the bright line; and the complete process of analysis corresponds to the determination of the complete spectrum of the source of light, which may consist of bright lines superimposed on a continuous spectrum. And the length of the series of observations corresponds simply to the resolving power of the optical apparatus. The only point in which the analogy breaks down is unfortunately that of ease and simplicity. In the optical analogy, an optical instrument performs for us with completeness and despatch the analysis, which in its counterpart must be performed by ourselves with much numerical labour.

Let us consider how we should most conveniently proceed to the complete delineation of a spectrum. We should ultimately need an apparatus of the greatest possible resolving power, but it might not be advisable to begin with it: on the contrary a small instrument which enabled us to glance through the whole spectrum might save much time. Suppose, for instance, that there was a bright line in the yellow; our small instrument might suffice to show us that it was due either to sodium or helium, but no more: the decision between these alternatives must be reserved for the larger instrument. On the other hand, if no line is seen in the yellow at all, we have ruled out both possibilities at once, and so economised labour. Hence it is natural to use first an instrument of low resolving power and afterwards one of higher.

Now in the work for which this serves as an analogy this procedure is actually imposed upon us by the march of events. It has been pointed out that the resolving power of the optical apparatus corresponds exactly to the length of our series of observations. Hence our resolving power is continually increasing. Quite naturally we begin with a short series of observations, which shows us our lines blurred and confused: to define and resolve them we have but one resource—'wait and see'; wait and accumulate more observations, to lengthen the series. But the lengthening must be in geometrical progression: we must double our series to increase the resolving-power in a definite ratio; and double it again. We begin to get a glimpse of the important part to be played by the observer in the future, and of his increase in numbers.

Let us glance at a few illustrations of the use of this method. Professor Schuster has applied it, for instance, to the observations of sunspots. Now it may fairly be said that the general law of sunspots was thought to be known: the variation in a cycle of about 11⅛ years has long been considered to represent the facts: it catches the eye at once in a diagram, and though there are also obvious anomalies, they had not been deemed worthy of any particular attention (with one exception presently to be mentioned), until Professor Schuster undertook his analysis. To his surprise, when he calculated the periodogram of sunspots, he found two entirely new facts:

Firstly, that there were other distinct periodicities, notably of about four, eight, and fourteen years;

Secondly, that the eleven-year cycle had not been continuously in action, but that during the eighteenth century it had been much less marked than the eight-year and fourteen-year cycles.

A further most interesting fact seems to emerge, viz., that several of the periodicities are harmonics of a major period of some thirty-three years or more, and it seems just possible that a connection may ultimately be established with the Leonid meteor-swarm, which revolves in this period. But it would take us too far from our main point to follow these most interesting corollaries: the point well worthy of our special attention is this, that we have here an undoubted

advance in knowledge resulting, not from observations made with regard to any particular theory, but from the simple collection of facts and the arrangement of them in all possible ways, the very method which has been despised and condemned. Let us contrast with this the method hitherto adopted, which has been to hunt for some particular possible cause which will give the eleven-year period. Thus Professor E. W. Brown suggested[2] in 1900 that the eleven-year cycle was due to the tidal action of Jupiter, altered periodically by two causes :—

	Period.	Mag. of Force.
By Jupiter's eccentricity	11·86 years . .	0·33
By the motion of Saturn	9·93 ,, . .	0·11

and he supports his contention by an ingenious and striking diagram, which seems to explain not only the main cycle, but its anomalies. (This Paper is in fact the exception above referred to.) But if his contention is correct the periodogram should show bright lines at 11·86 and 9·93 years, which it does not. This is worth noting, since it is sometimes said that there is nothing new in Professor Schuster's method, which is true enough in one sense, since it is simply the analysis of Fourier. The novelty consists, *firstly*, in calling attention to the necessity of applying the analysis in all cases, a necessity which I venture to think was overlooked in this instance by so able a mathematician as Professor Brown; and, *secondly*, in the insistence on the examination of *all* periods, irrespective of any particular theory or preconception. And in this second character the method seems to me to cut at the root of the canons of procedure which have found favour hitherto.

As a second instance I present with much more diffidence a few results which seem to emerge from a very laborious analysis of the rainfall at three or four stations, for which Professor Schuster and myself are jointly responsible. There is some evidence for a cycle of 600 days in the Greenwich rainfall to which a further cycle in the quarter period (150 days) lends support. On analysing the Padua records it is found that these cycles do not exist, but it seems quite possible that there are cycles of rather shorter period, viz., 594 days and 148½ days : the relation of four to one being maintained. The separate links in this chain are none of them very strong, but they seem to hang together, and there is certainly a case for further investigation. But would this case have been likely to present itself in any other way than by the examination of the whole periodogram ? I find it very difficult to think, even now the periods are suggested, of any theoretical cause : to let the facts speak for themselves took much time and labour, but I venture to think that we might have waited far longer, and cudgelled our brains much more, before we got the clue by formulating hypotheses of causation.

A new method is not adopted widely all at once. Professor Whittaker has, I am glad to say, begun to apply the method to variable star observations, and is already hopeful of having obtained valuable information in the case of the star *SS Cygni*. Possibly we may hear something from him at this meeting. Meanwhile I take the opportunity to remark that the history of variable star observation affords us many lessons as to the desirability of simply accumulating observations and letting them speak for themselves instead of being guided by a theory on hypothesis. Let me give an instance. One of the fathers of variable star-observing, the late N. R. Pogson, made a series of excellent observations of the star *R. Ursæ Majoris* in the years 1853 to 1860. He then seems to have formulated a particularly unfortunate hypothesis, viz., that he knew all about the variation; and he accordingly only made sporadic observations in succeeding years. Now this star, along with many others, varies in a manner which may be illustrated from the occurrence of sunrise. The average interval between two sunrises is exactly twenty-four hours : but this is only the average. In March the sun is rising two minutes earlier every day, and the interval is therefore two minutes short of twenty-four hours; as the year advances the daily gain slackens, and at mid-summer the interval is exactly twenty-four hours : then the sun begins to rise *later* each day, and the interval exceeds twenty-four hours and so on : so that there is a regular yearly swing backwards and forwards through a mean value : and as in the case of all such swings there is a sensible halt at the extreme values. Now when Pogson made his observations of *R. Ursæ Majoris*

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[2] *Monthly Notices R.A.S.*, lx., p. 600.

in 1853-60 it was time of halt at an extreme: the period remained stationary and the variation repeated itself eleven times in closely similar fashion, so that Pogson concluded it would continue in the same way. How many instances suffice for an induction? Many inductions have been based on fewer than eleven. Unfortunately the period was just beginning to change sensibly, and we lost much valuable information, for no one else repaired Pogson's neglect adequately: and the whole swing of period occupies about forty years, so that the opportunity of studying the changes he missed has only quite recently returned. We are thus reminded how disastrous may be a break in the record. It should be one of the articles of faith with an observer that the record is sacred and must not be broken. Most of them indeed act on that principle already, but there are heretics, and it pained us to find even Professor Schuster himself tinged with heresy. On the very occasion when he did so much for the observer by presenting his beautiful method, he suggested that it might even be advisable to drop observing for a time in order to apply the method to accumulated observations. He may possibly be right, but the observer had better believe him wrong. There ought to be an 'observer's promise' like the promise of the boy scout; and one part of it should be not to interrupt the record, and another should be to publish the observations regularly, and never to let them accumulate beyond five years.

The method of Professor Schuster is not the only one that has been recently proposed for dealing with large masses of observations. We have also the methods of Professor Karl Pearson. These have been far more widely adopted for use than the periodogram, and they have also been more adversely criticised. As regards criticism, I think it is fair to say that it has chiefly been directed towards the nature of the material on which Professor Pearson has used his process rather than on the process itself, and at present we need not be concerned with it. The processes themselves are sound enough; one of them, for instance, is much the same as the old method of least squares in a simple form. But if the same criticism is made as has been made on the method of the periodogram—viz., that it is not new, we can also reply in almost the same words in the two cases: the mathematical calculus may not be new, the novety is the insistence on the application of it, and the application to all possible cases. Professor Pearson ceases to look for one principal factor only, and examines all possible factors, just as Professor Schuster examines all possible frequencies. Let us recur for a moment to the words of Sir George Darwin previously quoted: -

> A mere catalogue of facts, however well arranged, has never led to any important scientific generalisation. For in any subject the facts are so numerous and many-sided that they only lead us to a conclusion when they are marshalled by the light of some leading idea.

Let us take, for instance, a catalogue of variable stars such as those of Mr. Chandler. Particulars for each star are given in separate columns, exclusive of the name and number. We might wait long for a leading idea to guide us in marshalling the facts, and so far as I know we have waited till now without any such idea occurring to anyone. But Professor Pearson insists on the plain duty of determining the correlation between each and every pair of these columns, and any others we may be able to add. Anybody could have made the suggestion, and there was plenty of elementary mathematical machinery in existence for carrying it out; but so far as I know nobody did, any more than the critics of Columbus suggested how to stand up an egg. But the suggestion having been made by Professor Pearson, it was so clearly sound that I did what lay in my power to follow it up: with the result that certain correlations were at once indicated which at least pave the way for further inquiry. If we cannot say more than this it is simply because the catalogue of facts was not large enough. So far from the observers having wasted their energies by observing without any theory to guide them, more work of the same kind would have been welcome, for it would have reduced the probable error of the correlations indicated. As an example I may quote the following. It has already been mentioned that a variable-star-maximum, though it may recur after a more or less definite period on the average, is subject to a swing to and fro like the time of sunrise. Let us call the average interval *the day* of the star and the period of swing *the year*, without implying anything more by those names than appears in the analogy.

Then I found[3] that the day and the year were correlated, the value of the coefficient being

$$r = 0{\cdot}56 \pm 0{\cdot}08.$$

Having obtained this clue it was interesting to use it for the elucidation of individual problems. The *days* of many stars are by this time pretty well known, but their *years* are very uncertain. In nine or ten cases the assessment of the vaguely known *year* was under revision, and in all, without exception, the revised assessment tended in the direction of the formula. In one case (*S Serpentis*) the formula suggested the solution of a long-standing puzzle.[4] Finally the inquiry is suggested whether our own sun may be treated as a variable star with a period or *day* of eleven years, in which case its time of swing a *year* should be about seventy-five years, if the formula is strictly linear. There are found to be indications of a swing of this order of magnitude, though the time given by the periodogram method is fifty-four years.[5] If the relation between *year* and *day* is not strictly linear these figures could easily be reconciled for a case lying so far outside the limits within which the formula was deduced. But the ultimate successful establishment of the connection is of less importance for our present purpose than to notice the fruitfulness of the method of suggestion, which is as mechanical as Bacon himself could have wished.

Let us admit frankly that there is an appearance of brutality about such methods. Is our method of search to be merely the old and prosaic one of leaving no stone unturned? We have been led to believe that there should be more of inspiration in it; that a true man of science should have some of the qualities of that fascinating hero of fiction, Mr. Sherlock Holmes, who picks up his clue and follows it unerringly to the triumphant conclusion. Such qualities will do the man of science no possible harm: indeed they will be of the utmost value to him. The point to which I am now calling attention is the change in nature of the opportunities for using them, which are becoming every day more confused. Sir Conan Doyle, in the exercise of his art, keeps our attention fixed on a single trail: he conceals from us by mere omission the numerous trails which cross it. We admire the skill of the Indian who pursues an enemy through the trackless forest: but his success depends on the simplicity brought by this very tracklessness, and would be imperilled if there were numerous tracks. It may be remarked, however, that there is a still higher sagacity—that of the hound who even among a number of tracks can pick out the right one by scent. Let us imagine for a moment that the scientific man can be endowed in the future, by training or by some new invention, with a faculty of this kind, so that he may unerringly pursue a single trail even when it is crossed and recrossed by others. Then in the terms of this metaphor I draw attention to the fact that he has still to determine which is the right trail; and that in general he can only do so by pursuing each in turn to the end. To take an example from recent scientific anecdote: I relate the story as I was told it, and even if incorrect in detail it will serve its purpose as a parable. The Röntgen rays were discovered originally by their photographic action, but afterwards it was found that they would render a screen of calcium tungstate phosphorescent. I was told that this discovery had been made in this wise: Mr. Edison had a large collection of different chemicals, and a number of assistants: he set his assistants busily to work to try each substance in turn until the right one was found. Now this is not only a genuine scientific process, but it is *the fundamental process.* Let it be frankly admitted that our instincts are against it. We should much prefer to hear that some *hypothesis* had pointed the way, even a false hypothesis such as actually led to the discovery of the possibility of achromatism in lenses. Or if *memory* had played a part: The other day Professor Fowler identified the spectrum of a comet's tail with one taken in his laboratory, of which he had some recollection, and our human sympathies fasten at once on this idea of recollection as a praiseworthy element in the discovery. Nay, even mere *accident* appeals to us more than brutal industry: if Mr. Edison had wandered into his laboratory, picked up a bottle at random, and found it answer his purpose, I venture to say that we should have instinctively awarded him more merit: there would have been just a chance that he was

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[3] *Monthly Notices R.A.S.*, lxviii., p. 544.

[4] *Ibid.*, lxviii., p. 561.

[5] *Ibid.*, p. 659.

inspired. Let us by all means welcome hypothesis, memory, inspiration, and accident whenever and wherever they will help us: but they may fail, and then our only resource is to help ourselves by the unfailing method of examining all possibilities. The aid of the others is adventitious and comes, like that of the gods, most readily to those who help themselves.

The maxim of 'leaving no stone unturned' was enunciated from a rather different point of view some dozen years ago by an American geologist, Professor T. C. Chamberlin, of Chicago, in a short paper for students entitled 'The Method of Multiple Working Hypotheses.'[6] After recalling how much the march of science in early days was retarded by the tyranny of a theory formulated too hastily, and how in later times attempts have been made to remedy this evil by holding the theory, provisionally only, as a working hypothesis, Professor Chamberlin points out that even the working hypothesis has serious disadvantages:—

> Instinctively there is a special searching-out of phenomena that support it, for the mind is led by its desires. . . . From an unduly favoured child it readily grows to be a master and leads its author whithersoever it will. . . . Unless the theory happens perchance to be the true one, all hope of the best results is gone. To be sure truth may be brought forth by an investigator dominated by a false ruling idea. His very errors may indeed stimulate investigation on the part of others. But the condition is scarcely the less unfortunate.
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> . . . .
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> To avoid this grave danger the method of multiple working hypotheses is urged. It differs from the simple working hypothesis in that it distributes the effort and divides the affections. . . . In developing the multiple hypotheses, the effort is to bring up into view every rational explanation of the phenomenon in hand and to develop every tenable hypothesis as to its nature, cause, or origin, and to give all of these as impartially as possible a working form and a due place in the investigation. The investigator thus becomes the parent of a family of hypotheses: and by his parental relations to all is morally forbidden to fasten his affections unduly upon any one. In the very nature of the case, the chief danger that springs from affection is counteracted.

For the further elucidation of Professor Chamberlin's proposals I must refer my audience to his original paper, which is well worthy of careful attention. He does not shirk consideration of the drawbacks—'No good thing is without its drawbacks,' he writes. And it may be added that no good thing is entirely new, or entirely old. Perhaps it is better to say that it is generally both new and old. The Method of Multiple Hypotheses is new because it is still necessary to remind scientific workers of all kinds that so long as they restrict themselves to the examination of one hypothesis only they can never reach complete logical proof: they can only attain a high measure of probability. What is often called verification[7] is not complete proof, but only increase in probability: for

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[6] University of Chicago Press, 1897.

[7] To show that the facts agree with the consequences of our hypothesis is not to prove it true. To show that is often called *verification*: and to mistake verification for proof is to commit the fallacy of the consequent, the fallacy of thinking that, because, if the hypothesis were true, certain facts would follow, therefore, since those facts are found, the hypothesis is true. . . . A theory whose consequences conflict with the facts cannot be true; but so long as there may be more than one giving the same consequences, the agreement of the facts with one of them furnishes no ground for choosing between it and the others. Nevertheless in practice we often have to be content with verification; or to take our inability to find any other equally satisfactory theory as equivalent to there being none other. In such matters we must consider what is called the weight of the evidence for a theory which is not rigorously proved. But no one has shown how weight of evidence can be mechanically estimated; the wisest men, and best acquainted with the matter in hand, are oftenest right.—*An Introduction to Logic*, by H. W. B. Joseph, Fellow and Tutor of New College, Oxford. Clarendon Press, 1906, p. 486.

complete proof it is necessary to show that no other hypothesis will suit the facts equally well, and thus we are bound to consider other possible hypotheses even in the direct establishment of one.

But the method is also old in that it has long been adopted in practice, however partially and unconsciously, by scientific workers of all kinds. When as a boy at school I began to make physical measurements under Mr. J. G. McGregor (now Professor of Physics at Edinburgh) I learnt from him one golden rule: 'Reverse everything that can be reversed.' The crisp form of the rule may be new to many who have long used it in their work: and its use is simply that of 'multiple hypotheses.' For when the current in a wire is reversed, the hypothesis is tacitly made that the effect observed may be due to the direction of the current: and when a measured spectrum photograph is turned round and remeasured, it is an admission of the hypothesis that the direction of measurement may be partly responsible for the observed displacements of the spectrum lines. By the various reversals we endeavour, in Professor Chamberlin's words, 'to bring up into view every rational explanation of the phenomenon in hand' which can be brought up into view in this way But truly 'no good thing is without its drawbacks,' and one drawback to the recognition of this principle is that, by a process of mental confusion, it seems sometimes to be regarded as a distinct merit in a piece of apparatus that it can be reversed in a large number of ways. It must be remembered that the hypotheses thus examined and ruled out are chiefly instrumental ones superadded to those of Nature: and the latter are already sufficiently numerous, without our ingenious additions.

The view which I have endeavoured to put before you of the inevitable course of scientific work is that it will depend more and more on the patient process of 'leaving no stone unturned.' It may not be an inspiring view, but it should be at least encouraging, for it follows that no good honest work is thrown away. And it is just this encouragement of which the observer, as opposed to the worker in the laboratory and the mathematician, stands sometimes in sore need. The worker in the laboratory can often clear away his hypotheses on the spot: he can reverse his current then and there: but this is often impossible for the observer, who can and does reverse his spectrum plate for measurement, but to reverse the motion of the earth which affected the lines must wait six months: and to reverse also the motion of the star may have to wait six years, or sixty, or sixty thousand. In many cases he must leave the reversal to others, and thus not only can he not test all his hypotheses, but he may not even be able to formulate them. His aim cannot therefore be to establish within his lifetime some new law, and his work is not therefore to be appreciated or condemned by his success or failure in this respect. There are truer aims and surer methods of judgment. Something is inevitably lost when we endeavour to express these aims in the concrete; but for the sake of illustration we may say that the true observer is always endeavouring to reach the next decimal place, and is ever on the alert for some new event. Of the pursuit of the next decimal place it is needless to say more · the aim is as familiar in the laboratory as in the observatory. But I often think that the recognition of new events is scarcely given its proper place in the annals of science, if we have due regard to the consequences. I have protested that in much of his work the observer cannot be judged by the fruits of his labour, though there is an instinctive tendency to judge in this way: but here is a case where he might well be content to be so judged, and yet the consistent award is often withheld. Think for a moment of the very considerable additions to our knowledge which have accrued from the discovery by Professor W. H. Pickering of a Ninth Satellite to Saturn. The discovery led directly to the recognition of the retrograde motion; and to explain this we were led to revise completely our views of the past history of the Solar system. Incidentally it stimulated the search for other new satellites, resulting in the discovery of a curious pair to Jupiter and next of the extraordinary Eighth Satellite; while it was the investigation of the orbit of this curiosity which suggested an eminently successful method of work on Cometary orbits. If we judge scientific work by its results we must take into account all this subsequent history in our appreciation of Professor Pickering's achievement. But whether we do so or not is probably a matter of indifference to him, for the true observer is,

above all things an amateur, using the word in that splendid sense to which Professor Hale recently introduced us. There have been many attempts to define an amateur. One was given by Professor Schuster in his eloquent address to this Section at Edinburgh in 1892:—

> We may perhaps best define an amateur as one who learns his science as he wants it and when he wants it. I should call Faraday an amateur.

We need not quarrel with his definition and certainly not with the noble instance with which he points it. But, after all, I prefer the definition of Professor Hale[8]:

> According to my view, the amateur is the man who works in astronomy because he cannot help it, because he would rather do such work than anything else in the world, and who therefore cares little for hampering traditions or for difficulties of any kind.

The wholly satisfactory nature of this view is that it provides not only a definition, but an ambition, and a criterion. We feel at once the ambition to become amateurs, for I deny stoutly that the distinction is conferred at birth: it comes with work of the right kind. And we may know what is work of the right kind by this if by nothing else: that by diligently performing it we shall become amateurs who find it impossible to stop: 'who work in astronomy because we cannot help it.' Before an army of such men even the vast hordes of dusky possibilities of which we are beginning to catch glimpses must yield. The fight may seem, and no doubt is, without end; and the opportunities for glorious deeds by which outlying whole troops of the enemy are demolished at once are becoming rarer. We are confronted with the necessity of attacking each possibility singly, which threatens the stopping of the conflict through sheer weariness. Clearly the army of amateurs is the right one for the work: weariness cannot touch them: they will go on fighting automatically because 'they cannot help it.'

The following Papers and Reports were then read:—

1. *The Earth as a Radiator.* *By* Professor W. J. Humphreys.

Obviously, since our climates are not now perceptibly growing either colder or warmer, the total amount of heat received by the earth during the course of a year is substantially equal to its loss of energy through radiation during the same time. But this equality of gain and loss does not apply to limited areas, and therefore to map the earth as a radiator it is necessary first to obtain temperature records above the level of vertical convection, or within the 'isothermal region,' where radiation alone is the controlling factor. Now the temperature of the 'isothermal region' is known for many places, as is also the average intensity of the earth's radiation, and hence it is possible to compute, with more or less accuracy, the absolute intensities of the earth's radiation at different latitudes. The following table is based on the assumption that the intensities of earth radiation are to each other directly as the fourth powers of the corresponding temperatures of the 'isothermal region':—

Gram-calories of Earth Radiation per Square Centimetre per Minute at Different Latitudes.

Latitude	0°-10°	10°-20°	20°-30°	30°-65°	65°-70°	70°-90°
Radiation Intensity .	0·26	0·27	0·31	0·34	0·31	0·27

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[8] *Monthly Notices R.A.S.*, lxviii., p. 64.

2. *On the Atomic Structure of the Elements, with Theoretical Determinations of their Atomic Weights.* *By* J. W. NICHOLSON, *M.A., D.Sc.*

This paper dealt with the inner structure of the chemical atoms, and gave a selected portion of a more general theory. This theory is based on a conception of positive electricity as existing in volume distributions of uniform density. The four most elementary atoms, representing the most primitive types of matter, have respectively two, three, four, and five electrons in the atom, with the quantity of positive electricity required to render the atom electrically neutral.

The inertia of an atom is regarded as the sum of the inertias of its positive and negative charges, the latter being of a lower order of magnitude. For a single charge of either sign, the inertia is proportional to radius charge.

The elementary atoms or 'protyles' above are identified with four elementary substances. The atom with two electrons, lighter than that of Hydrogen, is believed to be an inert gas, Coronium, found in the solar corona. That with three electrons is Hydrogen. The atom with four is called Nebulium, the main basis of the simpler nebulæ whose spectra consist of three bright lines, one being a Hydrogen line. The third bright line in these spectra is ascribed to the protyle with five electrons, called Protofluorine. Perhaps further evidence would need an interchange of these names. It is possible to build up all the atomic weights by simple groupings of three of these primary elements, these atomic weights being always within the limit of error of the experimental determinations by chemical methods. In this process, allowance is made for the fact that although the weight is mainly due to positive electricity, some portion is caused by electrons. It is found that a combination, for example, of one atom of protofluorine with one of nebulium—a combination which would readily occur and be very permanent—would have a molecular weight of 3·988, which is in close accord with 3·99, the atomic weight of helium. It is easy to see why this should be an inert gas. Moreover, its appearance immediately after the three bright lines in the slightly more developed nebulæ is a striking confirmation of the theory.

The author then proceeded with a detailed discussion of the inert gases and emanations, and showed that a very similar constitution, in terms of certain constantly-recurring groups of protyles with definite valencies, could be assigned all the inert gases, known and unknown. This theory leads to an atomic weight of 226·8 for radium, indicating that its ultimate product is lead, and also to the conclusion that the thorium emanation is that of radium with the groupings of protyles arranged differently.

From Russ's experiments it becomes possible to find the molecular weight of actinium emanation. It was shown that this emanation fits exactly into one of the vacant spaces in the Neon group of gases, and the corresponding atomic weight of actinium is 165·6. Actinium, therefore, falls between terbium and erbium, and is a member of the same group of elements as radium.

The groupings of protyles in the inert gases are only a part of a systematic set for all the elements. If the protyles are denoted by Cn, H, Nu, Pf, and unknown gases by X_r, we have the following table :—

Gas	Formula	Atomic Weight Calculated	Observed or Predicted
Helium	$He = NuPf$	3·99	3·99
Argon	$5He_2$	39·88	39·88
Krypton	$5\{Nu_4(PfH)_2\}$	83·0	82·9
Xenon	$5\{He_4(PfH_2)\}$	130·29	130·2
X_1	$5\{He_2(PfH)_2 . Nu_4(PfH)_2\}$	175·35	about 176 (predicted)
Ra. Em.	$2\{3He_4(PfH)_2 . 2Nu_4(PfH)_2\}$	222·8	222·4 (predicted)

Gas	Formula	Atomic Weight Calculated	Observed or Predicted
Coronium	Cn	0·51	about 0·4 (Mendeléeff)
Neon	$2(PfH)_3$	20·21	20·2
X_3	$2\{He_2(PfH)_8 . Nu_2(PfH)_8\}$	63·68	about 63 (predicted)
X_2	$2\{He_4(PfH)_8 . 2Nu_2(PfH)_2\}$	107·16	about 107 (predicted)
Act. Em.	$4\{He_4(PfH)_8 . Nu_2(PfH)_3\}$	157·6	about 157 (predicted as *unknown* gas).

3. *Report of the Committee to aid in Establishing a Solar Observatory in Australia.*—See Reports, p. 25.

4. *Report on Magnetic Observations at Falmouth Observatory.* See Reports, p. 78.

FRIDAY, SEPTEMBER 1.

Discussion on the Principle of Relativity. Opened by E. CUNNINGHAM. See p. 236.

DEPARTMENT OF MATHEMATICS.

The following Papers and Report were read :—

1. *On Mersenne's Numbers. By* Lieut.-Col. ALLAN CUNNINGHAM, *R.E.*

These are of form $M_q=(2^q-1)$, with *q prime*.

A pretty full account of all that was then known about these numbers was given by Mr. W. W. Rouse Ball in a paper in 'Messenger of Mathematics,' vol. xxi., 1892; three omissions occur in that paper (about numbers proved by Ed. Lucas), viz.,

M_{67}, M_{89}, known to be *composite*; M_{127} known to be *prime*. Since 1892 the progress has been as follows:—

$M_{67}=193707721 \cdot 761838257287$; due to F. N. Cole		1903
$M_{71}=228479 \cdot 48544121 \cdot 212885833$		

$M_{67}=193707721\cdot761838257287$; due to F. N. Cole 1903
$M_{71}=228479\cdot103343556363337793$* ⎫ due to the ⎧ 1909
$M_{163}\equiv0$ (mod. 150287) . . ⎬ present ⎨ 1908
$M_{197}\equiv0$ (mod. 7487) . . . ⎭ writer ⎩ 1895
$M_{181}\equiv0$ (mod. 43441); due to H. J. Woodall 1911

This leaves still unverified (as composite) only 15 out of the 44 numbers (with $q<257$) originally affirmed by Mersenne to be composite, viz., when

$q=101, 103, 107, 109, 137, 139, 149, 157, 167, 173, 193, 199, 227, 229, 241.$

A complete list of all the possible prime divisors < 1 million of these 15 still unverified numbers has been prepared by Mr. A. Gérardin (of Nancy, France) and the author jointly (but working independently). These 'trial divisors' have been tested by the author up to 500,000 without success (every 'trial divisor' was tried twice).

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* The composition of this large divisor is not known.

2. *Relations connecting the Branch Points and the Double Points of an Algebraic Curve.* *By* Professor J. C. FIELDS.

This paper concerns itself with an algebraic curve.

$$F(x, y) = y^n + F_{n-1}y^{n-1} + F_n = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

which presents no singularities at infinity and whose finite point singularities consist of nodes and ordinary cusps. On representing an arbitrary polynomial in (x, y) of degree $n-z$ by the notation.

$$G(x, y) = \sum_{r,s} d_{r,s}x^ry^s \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

a simple proof is given of the formula

$$\sum_\lambda c_\lambda \frac{G(a_\lambda, b_\lambda)}{F''_{b_\lambda}(a_\lambda, b_\lambda)} = d_{r,n-s} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where the summation is extended to all points (a_λ, b_λ) which are ordinary branch points, nodes or cusps of the curve, the coefficient c_λ having as value 1, 2, or 3, according as the corresponding point (a_λ, b_λ) is an ordinary branch point, a node or a cusp. If in particular for $G(x, y)$ we take the polynomial $F'_y(x, y)$ formula (3) reduces to one of Pluecker's formulæ. The proof of the formula is effected through representation of the function $\frac{dy}{dx}$ by the aid of partial fractions, on taking account of the fact that the degree of the reduced form of a rational function of (x, y) cannot be positive if the function possesses no infinity at infinity.

It may be noted that formula (3) was given by the author of the present paper for a more restricted case at the Ithaca meeting of the American Mathematical Society in 1901. In the paper here in question the proof of the formula has been greatly facilitated and abbreviated by the utilisation of the properties of the function $R(r, u)$ which presents itself in the writer's general theory of the algebraic functions.[1]

3. *The Infinitesimal Transformation of an Electromagnetic Field into Itself.* *By* H. BATEMAN, *M.A.*

4. *Report on the further Tabulation of Bessel and other Functions.* See Reports, p. 67.

DEPARTMENT OF GENERAL PHYSICS.

The following Papers were read :—

1. *On the Radiation producing Aurora Borealis.* *By* L. VEGARD.

Starting from the view advocated by Birkeland, that auroræ are caused by electric solar radiations, the author treats the problem of determining their physical properties.

From the form and structure of the luminosity a method is found of examining the way in which the solar rays are absorbed by matter, and he arrives at the conclusion that the law of absorption of the solar rays is essentially the same as that of α-rays. This coincidence with regard to law of absorption has led

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[1] "Theory of the Algebraic Functions of the Complex Variable." Berlin: Mayer and Müller, 1906.

the author to draw further consequences of the hypothesis that certain auroral forms are caused by α-rays.

It is found, from the relation between range and velocity, that α-rays will get down to heights varying between 70 and 300 km., which is the interval actually observed for most auroral forms. Further, calculations show that α-rays will strike the atmosphere at an angular distance from the magnetic axis of about 17°, which gives the right position of the auroral zone.

The question is treated whether a positive charge of the radiation is consistent with the diurnal distribution of aurora. The distribution found for a number of polar stations shows two distinct night maxima, and their existence is found to be in accordance with mathematical theory. The theory, however, in its present state is incomplete for a quantitative comparison with observations, and it cannot give any definite answer regarding the sign of charge. The explanation of thin drapery bands given by Stormer, however, is in favour of a *positive* radiation.

In order to explain the thin drapery bands a homogeneous radiation is necessary, and homogeneity is in fact a property of α-rays from a single radio-active substance.

The peculiarity of the draperies of showing series of equidistant bands is explained by assuming the radiation to consist of homogeneous groups starting under the same initial conditions. Such radiations necessary for the formation of parallel bands will be present if the source on the sun contain a radio-active substance and its various disintegration products. The parallel bands will give a kind of magnetic spectrum of α-rays characteristic of the radio-active substances in the source.

The author finds that the *α-ray* hypothesis, as far as our present knowledge goes, explains in a satisfactory way the properties of the definite auroral forms, while the assumption of a radiation of the *β-ray* type meets with serious difficulties.

2. *A Friction Permeameter.*[1] *By* W. H. F. MURDOCH, *B.Sc.*, *M.I.E.E.*

This instrument is a development of those described in a paper by the author, viz., 'Magnetic Testing of Iron.'[2]

The object of the arrangement is as follows: To keep the magnetic circuit invariable during a test, to keep the coefficient of friction constant, to have unidirectional sliding of the moving portion and no necessity to reset the specimen at each reading. To arrange matters so that the magnetic induction over the gap is as uniform as possible, so that the law of traction is fulfilled. To eliminate errors in H, the resistance of the magnetic circuit should be reduced to a minimum; the instrument also should be direct reading and portable.

The instrument consists of a specimen of cylindrical section, magnetised by a solenoid excited by an electric current, and entirely surrounded by a hollow cylindrical yoke of iron. This yoke is divided symmetrically at the middle and the lines of induction act on this gap together with other attractive forces. If now the top portion of the yoke is rotated about the specimen as a vertical axis, and slides steadily on the lower portion of the yoke, then the torque may be measured, or the angular displacement between the zero and pointer be read while sliding is occurring. To eliminate the friction pull previous to magnetisation the pointer is adjusted to read zero under mechanical friction only. Consequently when the specimen is magnetised the magnetic pull is taken up on the surfaced faces and the angular displacement is due to the magnetic induction only. Therefore the magnetic induction in the test specimen can be obtained by multiplying the square foot of the reading by a constant. Owing to the completeness of the magnetic circuit, tests at high inductions can be made and the results agree closely with ballistic tests besides possessing the advantage of great rapidity.

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[1] *Electrician*, vol. 67, p. 930.

[2] *Proc. Inst.E.E.*, vol. 40, p. 137.

3. *On the Methods and Apparatus used in Petroleum Testing.*

By J. A. HARKER, *D.Sc., F.R.S., and* W. F. HIGGINS, *B.Sc., A.R.C.S.*

An International Commission has recently been appointed to discuss the unification of the methods and apparatus used in petroleum testing. The National Physical Laboratory has joined in the work proposed by undertaking an investigation into the general methods and apparatus for the determination of the flash-point of petroleum used for illuminating purposes. The apparatus first studied include the well-known Abel tester, the official type used in this country, the Abel-Pensky as used in the British Colonies and India, and the German form of the same instrument. It has long been known that for some hitherto unexplained reason the Abel-Pensky apparatus gives a higher result for the same oil than the Abel; therefore in the testing of a cargo of oil it becomes a matter of importance as to which form of apparatus is used for the purpose. The object of the present paper is to determine the cause of these considerable differences before any steps are taken as to international agreement upon the matter. The Abel apparatus consists of a cylindrical brass oil-cup supported in an air-jacket surrounded by a water-bath adjusted to a definite temperature. The oil-cup is fitted with a cover which carries a thermometer divided into whole degrees Fahrenheit. The oil whose flash-point is required is filled into the oil-cup to the level indicated by a projecting point. Withdrawal of a sliding cover depresses a small test-flame a specified distance into the space above the oil. An ivory bead of specified diameter serves as a gauge in adjusting the flame to a uniform size. In making a determination of the flash-point the test-flame is applied to the vapour by pulling the slide as the mercury crosses each degree mark and this operation is timed by a pendulum or metronome. The exact timing was deemed to be of considerable importance when the original specification was issued. When the apparatus was adopted in 1880 by the German Government as their official standard, alterations in some details and dimensions were introduced by Pensky. The chief modifications consisted in the addition of a clockwork mechanism to open and close the slide automatically in the specified time and in the substitution of the Centigrade for the Fahrenheit temperature scale employed in the Abel apparatus. In this form the apparatus is known as the 'Abel-Pensky' type. The British Colonies and India in their official type (which is not legally recognised in England) adopted Pensky's automatic mechanism for the cover, but retained the dimensions and Fahrenheit scale of the English specification. Some preliminary investigations were made in order to study the effect of definite variations in the experimental conditions. The results obtained showed that large differences of temperature existed throughout the oil-cup and vapour-space above it at any stage in an experiment. To study adequately the distribution of temperature throughout the apparatus electrical means were used and the differences at various points were determined by means of sensitive, minute thermocouples of appropriate type. The general theory of flash-point determination depends on the hypothesis that flashing takes place when the space above the oil contains a definite percentage of oil-vapour mixed with air. This condition will be reached for a definite temperature of the oil from which evaporation is taking place, and it is generally assumed that it is this temperature which is given by the thermometer as the flash-point. The rate of evaporation, however, depends on the temperature of the surface of the oil, and the present observations show that this varies from point to point and at any moment differs appreciably from the thermometer reading. The temperature distribution depends in part on the exact form of the apparatus and on the relative amounts of heat reaching it from different sources. The difference above referred to frequently amounts to 5° F. and over, and is not the same, at corresponding readings of the thermometer, in the different types of apparatus. Measurements of the heating effect of the test-flame were also made and these showed that the size of the test-flame was of considerable importance—a fact which hitherto does not seem to have been adequately recognised. This heating effect is manifested mostly in the upper parts of the oil-cup, tending to raise the temperature of these parts above that of the rest of the oil. Now in the Abel-Pensky apparatus the cover contains a much greater amount of metal than in the Abel, and hence the former requires a greater amount of heat to raise its temperature by any definite

amount. This causes the temperature of the vapour-space and oil surface to rise less rapidly in the Abel-Pensky and a reasonable explanation is thus afforded of the differences between the two types. In addition, direct comparisons of the three types of apparatus were made with a series of oils of various flash-points. A practically constant systematic difference of slightly over 1° F. was found to exist between the Abel apparatus and the Colonial type of Abel-Pensky and a difference of nearly 4° F. between the Abel and the German Abel-Pensky.

The conclusions given in this abstract are based upon the results of about fifteen hundred experiments.

MONDAY, SEPTEMBER 4.

Joint Discussion with Section G on Aeronautics. Opened by A. E. BERRIMAN.—See page 481.

DEPARTMENT OF MATHEMATICS.

The following Papers were read :—

1. *Proofs of certain Theorems relating to Adjoint Orders of Coincidence.*

By Professor J. C. FIELDS.

In this Paper the author starts from an arbitrary algebraic equation.

$$F(r, u) = (u-P_1) \quad . \quad . \quad . \quad (u-P_n) = 0 \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where $P_1 \;.\;.\; P_n$ are power-series in an element $z-a$ (or $\frac{1}{z}$) with exponents integral or fractional. On adding $f\,(r, u)$ to the reduced form of any rational function of (r, u), such function can be represented in the form

$$(u - Q_1) \quad . \quad . \quad . \quad (u - Q_n) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

If the orders of coincidence of the rational function with the n branches of the equation corresponding to the value $r=a$ (or $r=\infty$) each exceed by 1 the orders of coincidence requisite to adjointness, on properly co-ordinating the series P and Q it is readily shown that we can write

$$\left.\begin{array}{l} Q_r = P^r + (r-a)^{a_r} S_r \\ \text{or} \\ Q_r = P_r + \left(\frac{1}{z}\right)^{a_r} S_r \end{array}\right\} \quad r = 1 \; . \; . \; . \; . \; , n$$

where the exponents a_r are > 0 and where the series S_r are integral with regard to the element $r-a\left(\text{or } \frac{1}{z}\right)$. On substituting these forms for the series Qr in the product (2) it is readily seen that the coefficient of u^{n-1} in the reduced form of the rational function represented by the product must be divisible by the element $r-a\left(\text{or } \frac{1}{z}\right)$. Where it is the value $r-a$ which is in question it is easily shown that the degree in (r, u) of the reduced form is $< N-1$ where N is the degree of $f\,(r, u)$. In the case of a finite value $r=a$ it furthermore follows that each coefficient in the reduced form is divisible by the element $r-a$ if the equation (1) is integral with regard to this element. The statements just made are evidently equivalent to the following theorems :—

(1) In the reduced form of a rational function of (r, u), which is adjoint for the value $r=a$ (or $r=\infty$), the coefficient of u^{n-1} is integral with regard to the element $r-a\left(\text{or } \frac{1}{z}\right)$.

(2) If a rational function is adjoint for the value $z = \infty$ the degree of its reduced form is $\leqq N-1$.

(3) The reduced form of a rational function, adjoint for the value $r=a$, is integral with regard to the element $r-a$ if the equation (1) is integral with regard to this element.

2. *A Theorem connected with Six Lines in Space.* *By* H. Bateman, *M.A.*

Let PP′, QQ′, RR′ be three pairs of non-intersecting straight lines. The locus of a point O, which is such that the three chords from O to the pairs of lines lie in a plane, is a quartic surface which contains the six lines PP′QQ′RR′.

If LL′, MM′, NN′ are the common transversals of QQ′RR′, RR′PP′, PP′QQ′, the quartic surface derived from LL′, MM′, NN′ is the same as that derived from PP′, QQ′, RR′.

If QQ′RR′ are generators of one system of a hyperboloid, there will be an infinite number of transversals of type LL′, and these will all lie on the hyperboloid. The hyperboloid must form part of the quartic surface, for in the general case the lines LL′, MM′, NN′ all lie on the quartic. The complete locus now consists of two hyperboloids, the one just mentioned and a second one, which must contain the lines MM′, NN′, PP′.

We thus have the theorem. If QQ′RR′ are non-intersecting generators of a hyperboloid and PP′ two arbitrary lines, the lines MM′NN′ are generators of a hyperboloid.

3. *The Canonical Form of an Orthogonal Substitution.*

By Harold Hilton.

Suppose $(X_1, X_2, \ldots, X_m)$ is a pole of a real orthogonal substitution A on the variables $x_1, x_2, \ldots, x_m$ which corresponds to a root λ of the characteristic equation of A; where $\lambda^2 \neq 1$. The inverse of the real orthogonal substitution B with matrix

$$\begin{vmatrix} b_{11} & b_{12} & \ldots & b_{1m} \\ b_{21} & b_{22} & \ldots & b_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ b_{m1} & b_{m2} & \ldots & b_{mm} \end{vmatrix}$$

where $b_{t1} = \frac{1}{2}(X_t+\overline{X}_t)$, $i\,b_{t2} = \frac{1}{2}(X_t-\overline{X}_t)$, $(t=1, 2, \ldots, m)$,
will transform A into a real orthogonal substitution, which splits up into a real orthogonal substitution on $x_3, x_4, \ldots, x_m$ only, and into the real orthogonal substitution

$$x_1' = \cos\theta\, x_1 - \sin\theta\, x_2, \quad \pm\; x_2' = \sin\theta\, x_1 + \cos\theta\, x_2.$$

If $\lambda^2=1$, we take

$$\begin{vmatrix} X_1 & X_2 & X_3 & \ldots & X_m \\ X_2 & \frac{X_2^2}{X_1+1}-1, & \frac{X_2X_3}{X_1+1} & \ldots & \frac{X_2X_m}{X_1+1} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ X_m & \frac{X_mX_2}{X_1+X} & \frac{X\,X_3}{X_1+X} & \ldots & \frac{X^2_m}{X_1+1} \end{vmatrix}$$

for the matrix of B, where $X_1^2+X_2^2+\ldots+X^2_m=1$, and obtain a similar result.

A similar process holds good for an *unreal* orthogonal substitution A, if and only if A has a simple invariant-factor.

If A is *real* and orthogonal, the process can be repeated as often as desired, and we thus obtain a practical method of transforming A into its well-known canonical form by means of a real orthogonal substitution.

Department of General Physics.

The following Papers were read :—

1. *The Absolute Measurement of Current at the Bureau of Standards.*

By Dr. N. E. Dorsey.

A balance of the type used by Lord Rayleigh was employed. The coils of square cross-section are wound bifilarly of enamel-insulated wire upon brass forms. A novel feature of the fixed coils is the provision in the forms and back of the windings of a channel through which water can be pumped so as to maintain the coils at a constant temperature. During the weighings the moving coil was surrounded by a double-walled jacket maintained at a constant temperature by water-circulation.

Three pairs of fixed coils (two 50 cm. in diameter and of thirty-six layers each of eighteen double turns, and one of 40 cm. diameter and twenty-eight layers of fourteen double turns each) and two moving coils (one 25 cm. in diameter and of twelve layers of six double turns, the other 20 cm. in diameter and of fourteen layers of seven double turns) were used in the final work. In the earlier work two other moving coils not well suited for absolute results were used.

All portions of the instrument have been tested by means of a very sensitive astatic magnetometer and have been found to be good. The insulation of the coils has been excellent throughout the work.

After winding, the coils were carefully sealed with paraffined cloth and paraffin, and covered by a layer of softer wax. The windings are thus well protected from changes in the atmospheric humidity. The distance between the two fixed coils was always such that the sum of the forces which they exerted upon the moving coil was a maximum. Under this condition the maximum force for a given current depends solely upon the ratios of the diameter of the moving coil to those of the fixed coils. Consequently the actual distance between the fixed coils need not be measured. This is a great advantage. The ratios of the diameters of the coils were obtained by a modification of the electrical method used by Lord Rayleigh. The settings of the coils and of the needle were adjusted by electrical methods; and the variations in the diameters produced by variations in the temperature and in the load carried were carefully studied experimentally. It has been found to be practicable to attain such an accuracy in the measurement of the ratio of the galvanometer constants of such coils that the mean variation from the mean of ten or more measurements shall amount to but two in a million. The correct adjustment of the coils was determined electrically, and an electrical method was devised for detecting and correcting for any slight error that might exist in the spacing or in the coaxiality of the fixed coils. The horizontality of the coils was tested by means of delicate levels.

While the earlier results are more erratic than the later ones, they give the same mean value. However, the conditions under which they were obtained were much less satisfactory than those secured later, and consequently only the later values have been considered in obtaining the final conclusion. These observations give the following values for the electromotive force of the mean Weston normal cell (as defined at the Washington Conference) at 20° C. in terms of the international ohm and the Bureau of Standards' balances :—

Coils		E. M. F.	Deviation from Mean
Moving	Fixed		
M2, $r=12{\cdot}5$ cm.	L3 . L4, $R=25{\cdot}0$ cm.	$1{\cdot}01822_8$	4×10^{-6}
M3, $r=10{\cdot}0$ cm.	L3 . L4, $R=25{\cdot}0$ cm.	$1{\cdot}01820_5$	10×10^{-6}
M3, $r=10{\cdot}0$ cm.	L1 . L2, $R=25{\cdot}0$ cm.	$1{\cdot}01822_7$	3×10^{-6}
M3, $r=10{\cdot}0$ cm.	S1 . S2, $R=20{\cdot}0$ cm.	$1{\cdot}01823_5$	11×10^{-6}
	Mean	$1{\cdot}01822_4$	9×10^{-6}

This value, 1·01822, differs from that obtained at the National Physical Laboratory by 4 in 100,000, ours being the higher. Whether this represents a real difference in the results given by the two balances, or is an actual difference in the electromotive forces of the reference cells used, it is impossible at present to decide; but it is hoped that co-operative work by the two laboratories will enable us to arrive at a definite conclusion before the next meeting of this Association.

The instrument was designed by Professor E. B. Rosa and the entire work has been done under his direct supervision.

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2. *On Peculiarities in the Adsorption of Salts by Silica.*

By Professor F. T. Trouton, *Sc.D., F.R.S.*

If the adsorption by silica of salts from solution is carefully examined it is found to follow different laws according to the thickness of the adsorbed layer on the surface of the silica. If a curve be plotted to show the adsorption by silica for solutions of various strengths of any salt, where the ordinates represent weight of salt adsorbed per gramme of silica and the abscissæ the concentration of the solution, then up to a certain value of the layer the curve on the whole runs concave to the concentration axis, becoming at this point

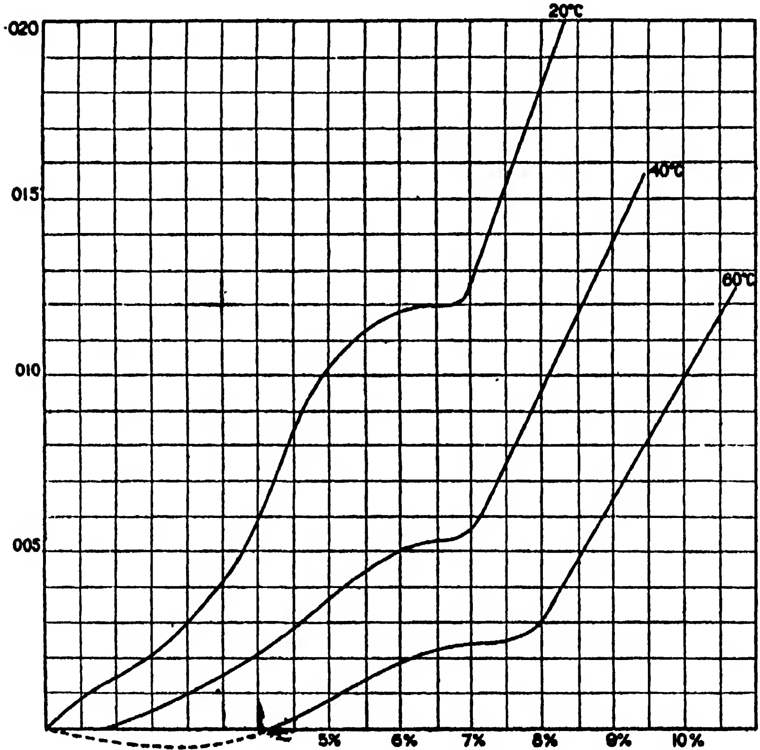

FIG. 1.

horizontal for a short distance, then turning upwards and passing on into the form of curve usually depicted.

The weight of salt adsorbed per gramme of silica at this critical point where the curve becomes horizontal (*i.e.*, at the point where the amount of the adsorbed layer is independent of the concentration) is found in the case of the chlorides to vary with the temperature, getting less as the temperature is raised, but in the case of those sulphates and nitrates which have been examined it is found to be independent of the temperature. Typical curves are shown in figs. 1 and 2.

By measuring the area of the surface of a gramme of the silica employed the weight of salt adsorbed per sq. cm. is known; with this object 'quartz wool' is best to use. If the density of the material of the adsorbed layer is known it is then possible to calculate its thickness; thus it has been found, by assuming the density of the salt in the adsorbed layer to be that in the solid state, that the thickness of the critical layer in the case of the sulphates and nitrates is of the order $10\ \mu$ (10^{-6} c.m.), while in the case of the chlorides the thickness of the critical layer approximates to a limit of the same order as the temperature is lowered.

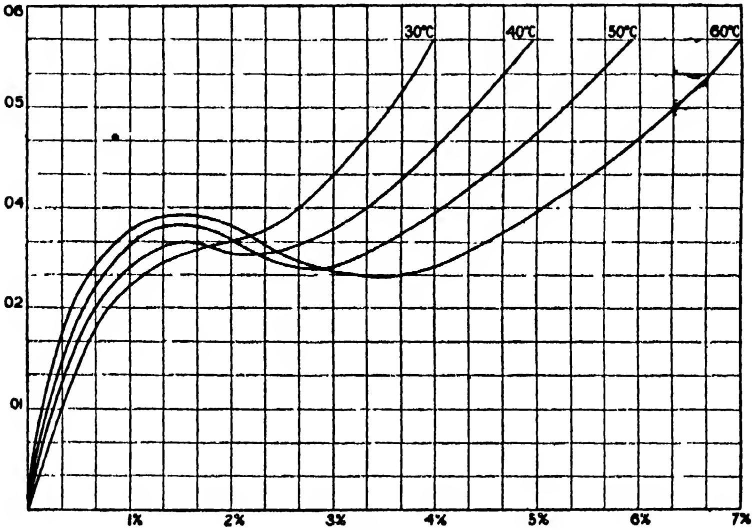

FIG. 2.

In some cases, particularly at higher temperatures, the adsorbtion curve, after becoming horizontal, turns actually downwards before passing on into its final form. So that at a certain strength of solution, increasing the concentration causes the silica to give up some of its adsorbed salt; that is to say, the layer at this point has become unstable for stronger concentrations.

This instability will recall the observations by Lord Rayleigh on the thickness of oil films on water, which showed that certain thicknesses of film were never formed. The experiments of Reinold and Rücker on soap films also show that certain thicknesses of film were unstable.

At the high temperatures in the case of the chlorides the curve shows that the adsorption is zero for quite considerable values of the concentrations. The form of the curve as it approached the concentration axis would look as if the curve crossed to the negative side of the axis and would suggest thus, that for small concentrations the force is repulsive, so that the pure water is adsorbed rather than the salt.[1]

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[1] This has since been verified experimentally.

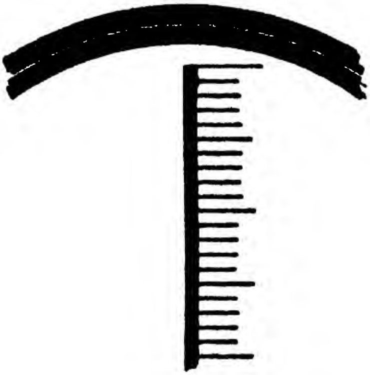
3. *The Effects of Air Currents on Sound.* *By* Professor F. R. Watson.

This problem is part of the larger one of curing the echoes and reverberation in the auditorium at the University of Illinois. Theory indicates that if the ventilating system be arranged so that a broad sheet of warm air move over the head of the speaker and be drawn out at the rear of the auditorium, it will act as a partition and, more or less completely, reflect and refract the speaker's utterances to the auditors. Lord Rayleigh has shown that reflection at the boundary of gaseous media depends on the difference in the velocities of sound in the two media. Taking $V=\sqrt{\gamma p/\rho}$, an increase in temperature or moisture decreases ρ and hence increases V. Total reflection may occur for very oblique incidence. With constant temperature, changes in p do not affect V, as p/ρ remains constant. If carbon dioxide is present, γ is less and V is decreased. Refraction also depends on the ratio of velocities, so that the sound which penetrates the moving stream is bent in the direction of the current with possibility of total reflection at the upper boundary of the stream. Furthermore, air in motion carries sound with it. These factors act to turn the sound to the audience, and, though each effect is small, the total effect may be large. Experiments verify theory and show that reflection takes place from hot gases rising from gas-jets so as to set up stationary waves.

4. *The Vernier Arc: A New Form of Micrometer.* *By* J. W. Gordon.

The model exhibited presents the micrometer on a very large scale, but is nevertheless capable as it stands of yielding measurements correct to one five-hundredth of an inch. On a scale suitable for the eyepiece of a microscope or telescope the accuracy of the reading would be limited only by the magnifying power of the eye lens.

The instrument consists of (1) a scale and divided arc mounted in the focal plane; and (2) a diffraction grating mounted behind the eye lens and immediately in front of the eye point.



Vernier Arc and Scale.

The effect of so mounting a diffraction grating is to produce in the field of the instrument two images formed by diffracted light of every object lying in the field. These images flank their original on either side; their orientation being determined by that of the diffraction grating. On a bright field these flanking images are too feebly illuminated to be at all conspicuous, but on a dark field they are easily seen.

Advantage is taken of the phenomena of the flanking image in the following way: A narrow black field is traced in the centre of the field of the instrument and, in apposition with this dark field on one side of it, a scale is ruled

in strong black lines. At one end of this narrow black field a broad black field is formed large enough to accommodate the vernier arc. The vernier arc is a thin white line traced on this dark field and split up by black divisions into ten segments. The diffraction grating produces two flanking images of this arc, which intersect each other and the original arc in a point determined by the angular position of the grating. As the same angular position of the grating causes the image of the scale to be projected upon the narrow dark field in a position which may be displaced upwards or downward from the true position of the scale, it follows that the displacement of the scale may be measured by observing the point of intersection on the vernier arc. In this way very accurate micrometer readings may be obtained.

This form of micrometer possesses many advantages over those in present use. In the first place, it is comparatively inexpensive to produce, and should, therefore, be much cheaper than any other instrument of equal accuracy. In the next place, as the scale lines do not cross the whole breadth of the field they do not obscure the object under measurement. It is, therefore, immaterial how bold the scale line is drawn, since measurements can be made to its edge. Thus the reading of the scale is facilitated. Lastly, the scale can be read in the field of the instrument where the vernier arc is displayed and there is no divided screw head or other external part to be examined for this purpose.

DEPARTMENT OF COSMICAL PHYSICS.

The following Papers and Report were read :—

1. *The Thunderstorms of July* 28 *and* 29, 1911.

By DR. W. N. SHAW, *F.R.S.*

On the afternoon of July 28 the western districts of London were visited by a severe thunderstorm, and in the afternoon and evening of the following days thunderstorms occurred over nearly the whole of England and Ireland. The London storm was accompanied by a squall of wind which reached fifty-four miles per hour at South Kensington, and the storms on July 29 were preceded by a violent squall which raised clouds of dust particularly noticeable in South Wales. There were also marked oscillations of the sea on the south-west coasts.

Meteorograms from records taken at the Meteorological Office at South Kensington were shown for both storms. That for July 28 was of the ordinary thunderstorm type—a sudden rise of pressure, which gradually fell off, accompanied by a drop of temperature of more than 20° F., a wind squall of fifty-four miles per hour with a change of direction probably from E. to S.W., and a rain shower giving an inch of rain in less than twenty minutes. For the following day the sudden rise of the barometer was followed by violent fluctuations : there was little fall of temperature, not much wind, and little rain.

Reproductions of barograms and anemograms from all parts of the country were exhibited in order to show the shape of the 'crochets d'orage' and the time of its occurrence at different stations.

They showed that the disturbance of July 28 was confined to the neighbourhood of London. That of July 29 was very widespread.

The most characteristic curve was that from Watlington, Oxon (Mr. W. H. Dines), which showed that the 'crochet d'orage' occurred while the passage of a depression was in progress, apparently just before the minimum was reached. The 'crochet' of disturbance gave an M-shaped figure, which it took about two hours to complete. A somewhat similar figure is noticeable at many other stations in the region to the south and west.

The weather maps showed that the storms of July 29 were incidental to the setting in of a south-westerly current of air, replacing an easterly current which had formed the northern part of a shallow low-pressure area to the south-west of Britain. By the following Sunday morning the new south-westerly current formed the eastern section of a well-developed cyclonic depression with its centre off the west of Ireland.

The barograms showed that the 'crochet' disturbances could be arranged

in isochronous lines indicating the advance of the 'crochet' with its attendant squall with a linear front, which passed Scilly at about 2 P.M. on July 29th. Over England the front was generally ranged from N.W. to S.E. and it advanced with the S.W. wind, but the lines were bent apparently over the Irish sea and the direction of the front over Ireland was not well traced. The disturbance advancing with this front was attended nearly everywhere by thunderstorms, but in the north of England its intensity was much diminished and it was barely recognisable in barograms for the north of Scotland on Sunday morning. The anemograms showed that at many stations in the south the wind squall commenced at the full strength of gale force without any preliminary gusts.

The peculiarity of the disturbance is its M shape and its line of advance in front of a S.W. wind. It is thus distinguished from the ordinary type of line squall, which has a V-shaped 'crochet' and comes from the W. or N.W.

The ordinary line squall is explained by the setting in of a cold current of westerly air which suddenly replaces a warmer current from S.W. or S. A similar explanation probably holds for the cases now under discussion, but the circumstances of the instability in the atmosphere which gave rise to the progressive thunderstorms are not so clear. The records of temperature, wind direction, and rainfall have still to be examined with the object of tracing the physical processes represented.

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2. *Report of the Seismological Committee.*—See Reports, p. 30.

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3. *Note on the Periodogram of Earthquake Frequency from Seven Years to Twenty Years. By* Professor H. H. TURNER, *F.R.S.*

1. The Catalogue of Large Earthquakes recently edited by Professor Milne makes it possible to examine the periodogram. The present note is restricted to the portion from seven years to twenty years. The methods of Professor Schuster for exhibiting the results of such an examination are still not very widely known, and are moreover capable of a variety of forms. Hence, enough of detail is given here to enable others to use the method if they wish.

2. Let us first consider the period seven years. To examine whether there is a seven-year periodicity we first arrange the yearly numbers in groups of seven years, and it is convenient to take five groups together, thus :—

Earthquakes recorded in 1700–1734.

	5	1	2	4	2	3	3	
	5	0	2	0	5	4	3	
	7	2	7	5	9	9	9	
	4	6	3	7	7	7	8	
	3	3	9	6	11	2	4	
Sum	24	12	23	22	34	25	27	=167
× sin θ	0	+9	+22	+10	−15	−24	−21	=−19
× cos θ	+24	+7	−5	−20	−31	−6	+17	=−14

The sums for the consecutive groups are first multiplied by sin θ and then by cos θ; putting θ successively equally to 0°, 51°, 103°, 154°, 206°, 257°, 309° (multiples of 360°/7). Now write

$$a = -19 \times 200/167 \qquad b = -14 \times 200/167 \qquad \tan {}^{1}a/b = 234^\circ$$
$$= -22{\cdot}8 \qquad\qquad = -16{\cdot}8 \qquad\qquad a^2 + b^2 = 802$$

The multiplication of a and b by the constant 200, and division by 167, the sum of all the numbers, is a comparatively new suggestion arising out of the present case, but applicable to other cases. When we record rainfall or sun-spots the average does not change seriously; but in the case of these earthquake records facilities of communication have changed it very greatly. Compare, for instance, the latest group

with the earliest given above. (When we group in 5×7 years we have the groups 1700–1734, 1735–1769, 1770–1804, 1805–1839, 1840–1874, and the years 1875–1899 do not suffice for another complete group.)

Earthquakes recorded in 1840–1874.

	11	23	7	14	14	21	26	
	28	20	16	14	31	32	36	
	28	36	30	32	37	24	26	
	35	43	31	33	23	29	32	
	41	36	28	34	30	34	32	
	—	—	—	—	—	—	—	
Sum	143	158	112	127	135	140	152	=967
$\times \sin\theta$	0	+ 124	+ 109	+ 55	− 59	− 137	− 119	= − 27
$\times \cos\theta$	+143	+ 99	− 25	− 114	− 122	− 31	+ 95	= + 45

It is clear that the −27 and +45, variations in a mean value of 967/7, represent essentially smaller quantities than the −19 and −14 previously, which are variations on a mean value of 167/7. We should express the quantities as percentages to get a fair comparison; and this suggests multiplying by 100 and dividing by the mean values 167/7 and 967/7. But the division seven is compensated in another way. If we had a term A sin θ, then on multiplying the seven values by sin θ and summing them we should get 7/2 (or if there were n terms we should get $n/2$). The seven thus cancels out and leaves finally

200/total number.

Thus in the second case we get

$a = -27 \times 200/967$ $b = +45 \times 200/967$ $\tan^{-1} a/b = 329°$
$= -5{\cdot}6$ $= + -9{\cdot}4$ $a^2 + b^2 = 120$

The phases $\tan^{-1} a/b$ are only needed when we get a suspected periodicity. In the first instance we only want the values of a^2+b^2, which are as below.

TABLE I.—*Values of* a^2+b^2.

Years	First Group	Second Group	Third Group	Fourth Group	Fifth Group
7	802	54	193	237	118
8	31	203	24	38	83
9	22	148	324	31	
10	55	348	202	32	
11	648	179	151		
12	481	20	52		
13	407	130	66		
14	466	186			
15	314	512			
16	275	153			
17	487	60			
18	552	8			
19	373	309			
20	112	26			

The difference in the number of groups is due to the fact that in 200 years we can only get two groups of 5×20 years; but we can get four groups of 5×10 years.

Now it is clear that the accidental variations in the early records are a much larger percentage of the whole than later. This is only natural. For instance, if the records for a whole year were lost, this would reduce the value of any minimum falling near it.

The correspondence of the groups is very roughly indicated by the broken line dividing the whole series into two: the mean value of a^2+b^2 for the earlier half is 300, and for the later half 140.

It seems also pretty clear that there is nothing likely to be a real periodicity in this part of the periodogram. For such a real periodicity the value of a^2+b^2 should be at least five times the average. Let us first consider possible periodicities of *exactly*

7, 8, 9, &c., years. Thus the value of a^2+b^2 ought to be (say) 1,500 in the earlier half *and* 700 in the later half: or if one of them falls short of this, there must be compensation in the other. No values approach this combination. In seven years the high value 802 in the first group is at once discounted by the low values 54 and 193 in the second and third. The best combination is, perhaps, that at 19 years, suggesting a nutational effect depending on the moon's nodes.

But what difference will it make if the true period differs somewhat from an exact number of years?

With one qualification, the case will be no better. It might at first seem that if the phase of the fluctuation in the first half did not accord with the phase in the second, we could improve matters by slightly altering the period so as to make the phases accord. But we have, as a matter of fact, tacitly assumed that the phases were already in accordance. If they are not, then the case for periodicity is so far weakened. Indeed, the table presents the case on the most favourable assumptions, not only for periodicities of the exact values indicated but for others of neighbouring values at the same time.

But with this qualification. If the true period is 19¼ years let us say, then by taking five periods together on the assumption of 19 years, we reduce the amplitude. The phases of the two extreme periods are a whole year out from that of the mean, *i.e.*, about 18°; and those of the two intermediates are 9° out. Hence the maximum will be $1+2\cos 9°+2\cos 18°=5-0{\cdot}12$ instead of 5, *i.e.*, is reduced in the ratio $1-0{\cdot}024$ to 1; and its square is reduced in the ratio $1-0{\cdot}048$ to 1. This is not very serious; but the reduction is much greater near seven years. If the true period were 7½ years the reduction of amplitude is

$$(1+2\cos 24°+2\cos 48°)/5=0{\cdot}83$$

and of the square is thus 0·69. Hence instead of a^2+b^2 exceeding the average five times (say) we need only look for $5\times 0{\cdot}69=3\tfrac{1}{2}$ times.

But a second glance at the table shows that no supposition we can make will grant even this lower indication. For illustration consider the case presented by the groups for 15 years, the second of which (512) is 3·6 times the mean value (140) of a^2+b^2 for the second half; but the 314 for the first group dilutes it considerably. If we deem the matter worthy of further examination we must take into account the phases. The following table shows the phases for the whole of the groups, and we see that a very slight adjustment would make 211° and 238° agree. But a *slight* adjustment will not suit our hypothesis that the period is sensibly different from 15 years, and that the amplitude has accordingly been reduced by taking five periods together. The change of phase in five periods must be that due to about 2½ years, *i.e.*, about one-sixth of a whole period or 60°. We can make this in the *direction* of the observed change, though it does not agree in amount. There is thus room for compromise; the further we depart from 15 years the more we can allow for the reduction due to five-year grouping, but against this must be set an increasing difference of phase between the two groups.

TABLE II.—*Phases for the same Groups as in Table I.*

Years	First Group	Second Group	Third Group	Fourth Group	Fifth Group
	°	°	°	°	°
7	234	7	77	86	329
8	248	25	240	66	106
9	143	110	120	2	
10	315	172	284	140	
11	233	331	287		
12	170	96	275		
13	61	246	8		
14	296	35			
15	211	238			
16	118	275			
17	32	242			
18	322	265			
19	280	270			
20	247	180			

The study of a few such cases shows how well the ground is covered by the few figures given, except perhaps near 7½, 8½, and 9½ years. To strengthen the investigation near these periods it is easy to calculate the values of a^2+b^2 from the numbers for 15, 17, and 19 years respectively, using sin 2 θ and cos 2 θ instead of sin θ and cos θ. The results are as follows and show that nothing has been missed:—

Years	First Group	Second Group
7½	120	13
8½	160	100
9½	192	15

The study of the periodogram for periods shorter than seven years is more profitably undertaken by forming numbers afresh for (say) every four months, so that in seven years there would be 21 observations. Beginning with 20 of these we can work down to seven, representing a period of 28 months; and then we could begin again with single months. The present note practically clears away the long periods which could be detected from available material; for it is doubtful whether existing observations could satisfactorily confirm any longer period than twenty years, from two hundred years of record only.

4. *Horizontal Pendulum Movements in relation to certain Phenomena.*

By F. Napier Denison, *F.R.Met.Soc.*

The object of this paper is to present in as brief and graphic a manner as possible the results of observations carried on upon the Pacific coast for a series of years.

In the autumn of 1898 a Milne horizontal pendulum was installed at Victoria, B.C., and is one of many throughout the world whose records furnish valuable data for the Seismological Committee. Apart from the shorter period vibrations as quakes, tremors, &c., so graphically shown upon these traces, the author became deeply interested in observing certain wanderings of the pendulum; some lasting for days and sufficient to necessitate adjusting the levelling screw to keep the free end of the pendulum upon the centre of the paper. Thinking these movements might be due to changes of atmospheric pressure, the author began keeping a continuous record of these changes from January 1899, by measuring the exact position of the boom each day at noon, and allowing for certain levelling adjustments necessary from time to time.

A daily curve from these observations was plotted for the years 1899 and 1900, and when studied with the Synoptic Weather Charts of the Pacific slope for the same period, it was shown that the pendulum which is placed in the meridian would swing towards the eastward when the barometer was highest over the Pacific slope, and in the opposite direction when the barometer was low in this vicinity. These movements often commenced some hours before the local barometer indicated an approaching change. These observations formed the material for a paper read in 1901 before the Royal Meteorological Society,[1] and in the autumn of that year further data upon the same subject was personally presented at the British Association meeting held at Glasgow.

Acting upon the advice of Sir George Darwin to continue the E.-W. pendulum observations, and to establish a N.-S. instrument, I have succeeded in keeping a continuous record of the former to the present time, and in January 1907 personally constructed another instrument. This one is mounted in the basement of the Post Office upon solid rock and is about five hundred feet distant from the E.W. pendulum, and is set to swing N.S.

In 1908 daily curves for both pendulums for the year 1907 were plotted. These when studied with the weather charts of this coast showed that both pendulums had a general tendency to move in the direction where the air

[1] 'The Seismograph as a Sensitive Barometer.'

pressure was greatest, and that a resultant direction of N.-W. and S.-E. was noticeable.[3]

A continuous daily curve has now been completed for the past twelve years from the E.-W. pendulum movements, and a two years' curve for the N.-S. instrument. In studying these curves one detects the presence of certain pronounced long period undulations possessing marked rhythmic characteristics too great to be caused by local meteorological conditions. These and their probable causes form the subject to be presented, while a detailed account of the shorter fluctuations will be described at a later date.

In the following table the mean monthly and annual position of the E.-W. pendulum from 1899 to 1910 is given:—

Mean Monthly and Annual Position of E.-W. Horizontal Pendulum.
(12 Years.)

—	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1899	242 1	218·7	251·1	255·0	253·4	252·2	245·6	233·7	222·4	203·9	208·1	195·6	234·0
1900	197·7	193·7	217·7	212·9	202·7	199·6	182·0	174·2	170·1	164·9	162·9	195·8	189 5
1901	188·3	188·7	202·6	207·8	218·1	212·3	205·2	203·6	191·2	190·5	199·0	204·6	200·6
1902	207·8	219 4	224·0	223·5	228 5	223·2	222·8	210·2	209·1	210·5	210·2	218·0	218 0
1903	233·2	233·5	235·9	244·9	248·7	255·5	253·0	253·2	248·8	247·6	216·7	258·0	246·6
1904	263·5	264·1	265·2	267·9	263·0	261·9	266·0	261·4	259·2	258·3	254·5	255·3	261·7
1905	258·6	252·9	270·7	267·8	269 1	280·0	283·9	288·3	274·4	262·5	264·4	263·3	269'2
1906	265·8	271·4	267·9	281·0	289·9	296·5	301·8	300·3	296·2	290·7	280·4	280·1	285·2
1907	268·1	281·2	281·9	281·9	285·9	288·1	288·9	286·3	282·5	277·7	274·7	273·1	280·9
1908	273·7	270·9	271·2	271·4	273·1	278·7	286·1	282 2	277·2	269·4	266·6	261·9	273·5
1909	263·5	281·0	284·1	287·0	287·5	289·9	287·8	289·9	288·2	284·4	274·9	270·3	282·3
1910	277 8	280·0	297·2	301·9	310·0	314·2	315·8	311·6	310·9	309·2	307·2	307·0	303·6
Total	2940·1	2980·5	3069·5	3103·9	3124·9	3152·1	3188·4	3098·9	3030·2	2969 6	2949·6	2983·0	3045·1
Avge.	245·0	248·4	255·8	258·7	260·4	262·7	261·5	258·2	252·5	247·5	245·8	248·6	253·76

A cursory glance along curve E convinces one that there is a marked semi-annual and annual movement throughout the twelve years presented.

When studied in detail we find, beginning with January 1899, there is a steady easterly swing until April, when until June a slight westerly movement occurs, followed by a pronounced and rapid westerly swing continuing until October, when, after two small easterly movements in November 1899 and January 1900, a westerly maximum is reached in February. This is followed in March by a pronounced eastward swing, followed throughout this year until November by a great westerly movement. Throughout the remainder of this curve the eastward movement reaches its maximum during the summer months and maximum west in winter.

With respect to an annual movement, there is clearly to be seen a predominant westerly swing during 1899 and to November 1900, when an almost equally strong force sets in in the opposite direction, and continues until the summer of 1906, when a westerly tendency is shown for two years, followed by an easterly progression which continues to 1910.

Curve E′, although for only the years 1909 and 1910, clearly indicates a southerly maximum movement about the time the easterly maximum occurs, while the extreme north movement is reached during the spring months. Before attempting to account for these movements the following data bearing upon other branches of this subject will be presented.

The writer has classified all quakes recorded upon the Victoria seismograph into two types, those originating within a radius of 1,000 miles of Victoria termed 'B,' and all others originating beyond this 1,000 mile radius termed 'A.'

The sum of 'A' and 'B' signifying all quakes recorded is represented by curve 'C' in fig. 1.

This curve clearly shows a maximum number of quakes occurred between September 1899 and January 1900, and another abnormal number is seen from

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[3] 'The Effect of Atmospheric Pressure upon the Earth's Surface,' *Royal Astr. Soc. Can.*, 1908. A paper on the same subject was read at the British Association Meeting at Winnipeg, 1909.

June to December 1900. The next pronounced maximum is well shown during 1906, and another in 1910.

In fig. 1 the dotted line represents the mean of the twelve years' pendulum results, and is termed the normal for curve E. Attention is drawn to curve E during 1904 respecting its small annual inequality and close proximity to the normal line, and also to the few quakes recorded during that year, while the years when E is furthest from the normal are usually periods of abnormal number of quakes, viz., 1900, 1906, and 1910.

In order to ascertain if any correspondence existed between colliery explosions, seismic frequency, and curve E, the United States Geological Survey kindly furnished me with the dates and distribution of all colliery gas explosions (obtainable) when five or more human lives were lost.

Crosses represent these in fig. 1, and are placed upon the months in which they occurred, while dots represent some of the great European disasters.

These appear to occur more frequently during the months of extreme pendulum movements, and particularly at or near to the westerly swings.

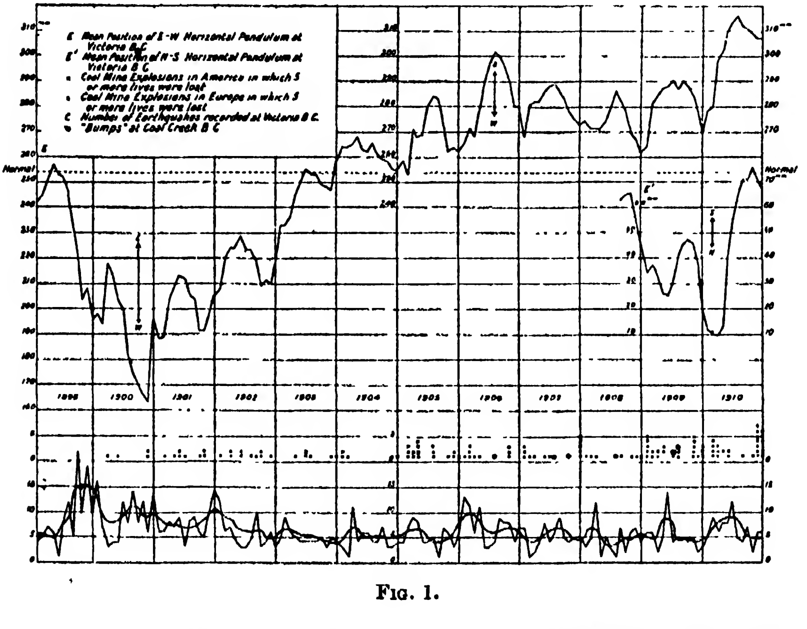

FIG. 1.

Attention is drawn to the remarkable absence of explosions in 1904, which is also the year of fewest quakes, also when curve E is nearest to its normal, while in 1909 and 1910 during the remarkable departure of curve E from its normal, the colliery explosions both in America and Europe increased alarmingly.

To carry this study still further the author during the autumn of 1910, and by the permission of his Director, Mr. R. F. Stupart, placed a horizontal pendulum of his own construction in the Western Fuel Company's mine at Nanaimo, V.I., at a depth of 979 feet. This instrument is under the sea and far removed from any working face, and by kind permission of the manager is read gratuitously twice daily. Eight months' curve from this instrument and from the surface instrument at Victoria have been plotted, and although the low level pendulum is liable to error until made self-recording, the corresponding Victoria curve, though more disturbed, parallels the former to a great extent.

In order to show to what extent temperature affects or controls curves E and E, the monthly mean temperature has been plotted in conjunction with these. The result demonstrates that from 1905 to 1910 one curve greatly resembles the other, while from 1899 to 1904 there are great differences between the two, although 'notches' are usually noticeable in curve E upon the months of maximum and minimum temperature.

Acting upon the advice of Sir George Darwin, who kindly furnished the necessary formulæ, I have separated the annual inequality from the 'march of zero,' and find the result bears out the seasonal and annual movements previously referred to in curve E, fig. 1.

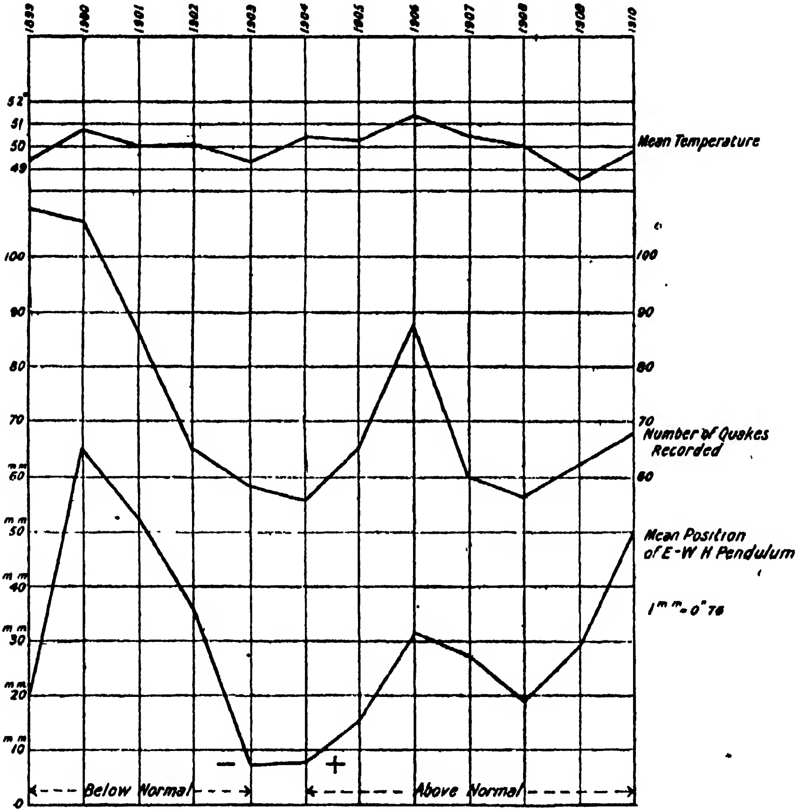

FIG. 2.

As certain not fully understood rhythmic changes prevail in magnetic curves, I have plotted the Toronto horizontal force for the entire twelve years in conjunction with curve E, and several years' magnetic intensity for Cheltenham, Md., and Honolulu, and find many interesting comparisons which when further developed may prove of value in helping to solve the origin of curve E, and explain certain magnetic phenomena.

The latitude variation curve for several years has also been studied in conjunction with E, and it is hoped when this comparison is more thoroughly pursued interesting results may be obtained.

Fig. 2 is given to show the annual position of curve E both above and

below its normal in conjunction with the annual quake frequency curve for Victoria. A study of these clearly demonstrates a remarkable correspondence between them. The annual mean temperature for Victoria is plotted above these curves in order to point out that the years of highest temperature, viz., 1900, 1906, and 1910, are the years when curve E is furthest from its normal position. With the exception of 1899 an agreement is also noticeable between the quake frequency curve and annual mean temperature.

In conclusion, although changes of temperature, barometric pressure, ocean tidal loading, snow in the mountains, and other local forces yet to be studied, may contribute to form curve E, the writer suggests that a certain proportion of this curve represents the presence of slow earth strains and movements ever active throughout the world, but more pronounced at Victoria, which is situated upon the great line of weakness and seismic zone extending from Alaska to Peru and Chile. The study of these earth strains and slow movements may therefore prove not only of scientific interest but of great practical value in determining the probable times when dangerous conditions might be expected in collieries, a further insight into earthquake phenomena, and even the force or forces causing these strains may have an important bearing upon the cyclic climatic changes known to exist throughout the world.

The author therefore suggests that the Association take steps to continue these researches in other portions of the Empire, in order to check what has been done and to throw more light upon this important subject.

5. *The Solar Cycle, and the Jamaica Rainfall and Earthquake Cycles.*

By MAXWELL HALL, *M.A., F.R.A.S.*

In the following table M marks maxima and *m* minima for sun-spots, the rainfall, and earthquakes in Jamaica. The earthquake statistics are given in the Third Report on Earthquakes in Jamaica which was issued by the Government of that Colony in 1907.

Year	Solar	Rainfall	Earthquakes
1870	M	—	—
1871	—	—	—
1872	—	*m*	M
1873	—	—	—
1874	—	—	—
1875	—	(*m*)	—
1876	—	—	—
1877	—	—	—
1878	*m*	—	—
1879		—	—
1880	—	*m*	*m*
1881	—	—	—
1882	—	—	—
1883	—	—	—
1884	M	*m*	—
1885	—	—	—
1886	—	—	M
1887	—	—	—
1888	—	—	—
1889	*m*	—	—
1890	—	*m*	—
1891	—	—	—
1892	—	—	*m*
1893	—	—	—
1894	M	—	—
1895	—	*m*	—
1896	—	—	M
1897	—	—	—

Year	Solar	Rainfall	Earthquakes
1898 . . .	—	—	—
1899 . . .	—	—	—
1900 . . .	*m*		
1901 . . .		—	—
1902 . . .	—	*m*	*m*
1903 . . .	—		—
1904 . . .		—	—
1905 . . .	M	—	—
1906 . . .	—	—	—
1907 . . .	—	*m*	M
1908 . . .	—	—	—
1909 . . .	—	—	—
1910 . . .	—	—	—

Excepting the rainfall minimum in 1875 the minima for rainfall follow solar maximum and minimum by one and a half or two years. The rainfall maximum between the minimum are more irregular.

The earthquake maxima follow the solar maxima by two years. The earthquake minima follow the solar minima by two or three years.

The droughts recorded in Jamaica history are as follow, see Long, Vol. III., p. 615: 'From October 1768 to May 1870 was the longest and severest drought ever remembered in the island.' In 1786 there was another great drought (Beckford, p. 63). Again, from the end of 1839 to the spring of 1841, and, lastly, in 1845. We thus get the following table:—

Droughts	Solar Epochs	Intervals
1769	*m* 1766·5	2·5 years.
1786	*m* 1784·7	1·3 ,,
1840	M 1837·2	2·8 ,,
1845	*m* 1843·5	1·5 ,,
	Average . . .	2 years.

Here again we see the droughts followed the solar maximum and minimum by about two years.

6. *Great Boundary Waves: Parallactic Tides set up in the Bottom Layers of the Sea by the Moon.* *By* Professor O. Petterson.

TUESDAY, SEPTEMBER 5.

Discussion on Stellar Distribution and Movements. Opened by A. S. Eddington, *M.A.*—See Reports, p. 246.

Department of General Physics and Astronomy.

The following Papers were read:—

1. *Corpuscular Radiation.* *By* Professor W. H. Bragg, *F.R.S.*

Corpuscular radiation may be defined as consisting of 'entities' or 'quanta,' each moving in a straight line with uniform velocity and unchanging properties unless impressed forces cause a change. It is a separate question whether corpuscular radiation is necessarily material. The α and β rays are corpuscular, but not sound

or light as usually conceived. The point to be considered now is the classification of X and γ rays.

The one certain property of the X or γ ray is its power of exciting a β-ray by encounter with an atom. The speed of the β-ray depends on the quality of the X-ray, but not on the nature of the atom, and its direction continues more or less the direction of the X-ray, more in the case of the penetrating γ-ray, less in the case of the 'softer' X-rays. Since β-rays produce ionisation, phosphorescence, and photographic action it may be true, and experiment actually proves, that these accompaniments of X-ray absorption are really due to the β-rays, the X-rays having no direct effects of this kind. The 'absorption coefficient' of a substance is simply a measure of its power of prompting the X-rays to produce β-rays.

The energy of the β-ray cannot come from the atom; for each atom would then have its own speed of ejection which, as well as the direction of projection, would be independent of the properties and conditions of the X-ray. Also there is no evidence of the existence of such induced radio-activity, implying the release of atomic energy.

Nor can the energy of the β-ray be the result of the accumulation in the atom of energy extracted from many X-rays. The arguments against the case just considered hold here also with little change: and it could hardly be supposed that the accession of the last infinitesimal amount of energy required to fill the store in the atom and provide for the energy of the β-ray would determine so effectively the direction in which the β-ray is ejected.

We must, therefore, suppose that *one* X-ray provides the energy for *one* β-ray; similarly that in the X-ray bulb, *one* β-ray excites *one* X-ray. I pointed out two years ago[1] that this was strongly supported by the near equality in speed of the β or cathode ray which produces the X-ray in the X-ray bulb to the speed of the β-ray which that X-ray finally produces. The figures were only approximately, though sufficiently, known at that time: the recent determinations of Whiddington have greatly strengthened the argument. It is clear that little energy is lost in the interchange of form, β to X ray and back again: and further, since the speed of the secondary β-ray is independent of the distance which the X-ray has travelled, the X-ray cannot diffuse its energy as it goes. That is to say, it is a 'corpuscle.' Moreover, it cannot spend energy on ionisation, a conclusion which I have verified.[2] The energy of an X corpuscle is given by the energy of the β-ray which it produces: and this definition is complete so far as is known. It is preferable to a definition by penetrating power, since the latter must have reference to some particular substance.

Barkla has shown that many substances emit homogeneous X-rays of characteristic penetrating power when irradiated by X-rays of greater penetrating power. In the language of the corpuscular theory, an X corpuscle of definite energy is frequently emitted by a substance which is under bombardment by X corpuscles of greater energy. As far as the energy relations go, this is what the corpuscular theory would lead us to expect. Whiddington has shown[3] that X-rays cannot excite the characteristic rays of any substance unless they have themselves been excited by cathode rays of energy exceeding a certain limit. This follows from the corpuscular theory. The requisite energy is that of the characteristic X corpuscle of that substance. The recent demonstration by C. T. R. Wilson of the tracks of ionising agents in a gas, tracks which are rendered visible to the eye by the condensation of water vapour upon them, are also illustrations of the theory.[4]

The corpuscular form of the X and γ ray, and its energy relations to the β-ray which is its origin, and the β-ray which is its conclusion are the principal things which any theory must account for, and any model must illustrate. For this reason the spreading pulse of Stokes fails: and so also does the kink in the tube of force of J. J. Thomson. The former diffuses its energy over a broadening surface, the latter over a lengthening line. It is true that certain phenomena suggest the existence of links between X-rays and light, such as the so-called polarisation of the former, and the photo-electric properties of the latter. But the nature of these links is not clear now, though it may be revealed more clearly in the future. The 'corpuscular theory' of X-rays is really an induction from experimental facts. The 'neutral-pair' theory which I have described at various times is at any rate a simple working model. But the 'ether-pulse theory' is at present little more than an aspiration.

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[1] Presidential Address to the Australasian Association for the Advancement of Science, Brisbane, January 1909.

[2] *Proc. Roy. Soc.*, **85**, p. 349.

[3] *Ibid.*, **85**, p. 323.

[4] *Ibid.*, **85**, p. 285.

2. *The Dependence of the Spectrum of an Element on its Atomic Weight.* *By* Professor W. M. Hicks, *D.Sc., F.R.S.*

In addition to the well-known series lines of a spectrum, a large number of others are directly related to them in the same way as the second or third set of a doublet or triplet series depends on the first, or as the satellite lines of a D series depend on the more intense set. The relation may be represented in the following way. The wave number of a line is given by a formula of the form $N/\{1 + D_1\}^2 - N/\{m + D\}^2$ which may be denoted for, say a S_1- series by $S_1(D_1) - VS\,(m)$. The S_2 series will then be denoted by $S_1(D_1 - W_1) - VS(m)$. As instances of one type of the relations in question, the following may be taken as examples amongst many others.

	λ			
Mg	4730.42	$S_1(D_1 - 42W_1 - 24W_2) - VS(1)$	0	·25
	4571.33	$S_1(D_1 - 45W_1 - 14W_2) - VS(1 + W2)$	0	·05
Ca	6169.87	$S_1(D_1) - V(1 - W_2)$	−·02	—
	6439.36	$S_1(D_1 + 2W_1 + 10W_2) - VS(1 + W_2)$	0	·10
	6462.75	$S_1(D_1 + 5W_1 + 5W_2) - VS(1 + W_2)$	−·04	·10
Sr	6550.53	$S_1(D_1 - 6W_2) - VS1$	0	·20
	6408.65	$S_1(D_1 - 7W_2) - VS(1 + 2W_2)$	0	·10

In the above the first column gives the wave length, the second the dependence on the atomic weight term W_1 or W_2, the third the difference between calculated and observed, on the supposition that the observed value for $S_1\,(1)$ is exact, and the last the limits of possible error. The examples are chosen from the sharp series—but the other series show similar connections.

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3. *On the Arc Spectra of certain Metals in the Infra-red Region* (λ 7600 *to* λ 10,000). *By* Major E. H. Hills, *F.R.S.*

In 1880 Abney showed that it was possible to prepare a collodion-bromide emulsion which was sensitive in the infra-red region about as far as λ10,000, and a few years later he published his now well-known map of this portion of the solar spectrum.

With one or two exceptions he did not extend his researches to include metallic spectra and since that time it does not appear that any other experimenter has followed up this line of work. For such observations of infra-red spectra as have been made either some form of bolometer or thermopile has been employed or, where photographic methods have been used, recourse has been had to plates stained with an organic dye. The latter method is not available beyond λ8,000, while with any form of thermopile method it is extremely difficult to attain adequate resolving power. It would appear that Abney's emulsion furnishes the best means of recording lines in this part of the spectrum and it is difficult to understand its total neglect by spectroscopic workers.

The importance of observing infra-red spectra lies not in the addition of a few new lines to the known metallic spectra, but in the fact that these new lines are just those most favourably situated for obtaining the laws governing series of spectrum lines, and therefore leading to fresh light on the interior dynamics of the molecule.

For the present research a spectroscope of two dense flint prisms was employed. Wave lengths were determined by comparisons with the sharp lines

in the solar spectrum, using Abney's wave lengths, corrected to accord with modern values, as the standards.

The wave lengths obtained are probably correct within one unit. Better results could be obtained with a grating, but very prolonged exposures would be required.

In the preparation of the emulsion Abney's prescription was generally followed, with some modifications in detail found advantageous in practice. A full description of the method of preparing such an emulsion with ease and certainty will be given in another place.

4. *The Specific Heats at High Temperatures and the Latent Heats of Metals. By* H. C. GREENWOOD, *M.Sc.*

PART I: ALUMINIUM AND ZINC.

This investigation was undertaken to provide more reliable data for the specific heats of metals at high temperatures than those at present available, particularly in the region of their melting-points, and also to determine the latent heats of fusion. The metals studied in the first stage were aluminium and zinc, on account of their comparatively low melting-points. In both cases the published data were very unsatisfactory. In order to carry out experiments above the melting-point the metals were sealed up in silica tubes, which were dropped, not directly into the calorimeter water, but into a funnel-shaped tube filled with light calcined magnesia. As the use of this entails a comparatively long intervals before thermal equilibrium is attained, special precautions were necessary to ensure maximum regularity and constancy in the cooling and heating conditions. Special attention was also devoted to an automatic arrangement for swinging round the furnaces over the calorimeter and dropping the specimen at the desired moment by the fusion of a platinum suspension loop. The furnace only approached the calorimeter just before dropping the specimen and at once returned to its original position. In this way the transfer of heat from the furnace to the calorimeter was rendered negligibly small and any radiation from the furnace was the same during the initial and final periods. Considerable difficulty was experienced in making up the specimens from the cracking of the silica envelopes as the metal inside expanded and contracted. Finally, however, by careful manipulation it was found possible to overcome the difficulty. The specific heat of fused silica being unknown it was necessary in the first place carefully to determine this, as the thermal equivalent of the silica envelope was a considerable fraction of the whole. This was the more necessary as the temperature coefficient of silica is fairly large. The curve for the mean specific heat of zinc was found to be continuous above and below the melting-point, while the latent heat of fusion was found to be about 26 gr. cals. per gram. In the case of aluminium the curve exhibited a sharp upward bend just below the melting-point, which is probably to be associated with a premature fusion of the metal. By including this heat evolution the latent heat was found to be about 95 gr. cals. per gram. The curve for the specific heat above the melting-point was found to be steeper than immediately below.

5. *On the Recent Eclipse. By* REV. A. L. CORTIE, *S.J.*

6. *On the Recent Eclipse. By* J. H. WORTHINGTON.

Department of Meteorology.

The following Papers and Report were read :—

1. *The Effect of the Labrador Current upon the Surface Temperature of the North Atlantic; and of the latter upon Air Temperature and Barometric Pressure over the British Islands. By* Commander M. W. C. Hepworth, *C.B., R.N.R.*

In a paper contributed to this Association by myself, in 1908, on 'A Comparison of the Changes in the Temperature of the Waters of the North Atlantic, and the Strength of the Trade Winds,' it was pointed out that evidence was not wanting to prove that deviations from the normal in the average distribution of surface temperature in the North Atlantic, during a series of months, are related, through the agency of the Gulf Stream, to departures from the average strength of the Trade Winds of the North and South Atlantic in the corresponding series of months of the previous year; notwithstanding the many causes affecting the temperature of the surface water, which tend to mask the appearance of such a connection.

The purpose of the present paper is to show by diagrams the effect of the Labrador Current, one of the most potential of the causes referred to, in modifying the Gulf Stream influence in the North Atlantic.

During the five years, 1903-07, increased activity of this current, evinced by an increase of ice in the North-Western Atlantic, was generally followed by a decline in the surface temperature of a part of the ocean represented by a zone between Florida Strait and Valencia.

Moreover, from a comparison of the surface temperature in that zone with air temperature and barometrical pressure at three stations in these Islands—Valencia, Sumburgh Head, and North Shields—it appears that a decline in sea temperature is frequently associated with a corresponding decline in air temperature at the stations named; and, to some extent, with an increase of pressure also, and *vice versâ.*

As regards ice frequency it should be understood from the outset that it is the cold ice-bearing current, not the ice it brings, that lowers the surface temperature of the ocean.

As best illustrating the correlations referred to above, the years 1903 and 1906 may be taken. In 1903 the abnormal quantity of ice brought south was associated with an almost persistent defect in sea temperature from May to December; a corresponding defect in air temperature, and, partially, an increase in pressure.

In 1906 the association of ice frequency with sea temperature and air temperature at the three stations was no less marked. With the failing activity of the Labrador Current in September and October, shown by declining ice frequency, sea temperature rose; and air temperature at the three stations, rising in August, remained about the normal during those months. The increase and diminution of pressure corresponding to the fall and rise of air temperature could also be traced except in May and September. In the latter month, however, an anti-cyclone became the dominating factor.

This year (1911) the quantity of ice increased rapidly from January to April and decreased as rapidly after May. The surface temperature of the North Atlantic, mainly in defect until April has been above the average since that month. Air temperature somewhat above the normal at the three stations in January and February declined in March, recovered in April, and has since been above the normal, considerably above in May, and since June.

2. *The Amount and Vertical Distribution of Water Vapour on Clear Days. By* Professor W. J. Humphreys.

It is of especial importance to anyone using a bolometer, or a pyrheliometer, to know the approximate amount of water-vapour through which the radiation reaching his instrument has passed.

To obtain this value the records of seventy-four balloon flights, some manned, the others free, made on cloudless days, have been assembled and studied. The results show that the amount of water-vapour per unit volume decreases with elevation in an approximate geometric ratio, and that the thickness of the water layer that would result from a condensation of all the water-vapour in the atmosphere above any given level, whatever the season, so long as only cloudless days are considered, may be approximately expressed by the equation,

$$d=2e,$$

in which d is the depth of the water layer in millimetres and e the partial pressure of the water-vapour in millimetres of mercury.

This is some 13 per cent. less than the value found by Hann as the average for all sorts of days, and heretofore used in bolometric work.

3. *Report on the Investigation of the Upper Atmosphere.*

See Reports, p. 27.

4. *A Theodolite for Observing Balloons.* *By* Dr. W. N. Shaw, *F.R.S.*

5. *Some Models representing Air-currents up to a Height of Nine Kilometres, based upon Observations with Pilot-balloons.* *By* Dr. W. N. Shaw, *F.R.S.*

6. *Planetary Circulation in the Atmosphere.* *By* Dr. H. N. Dickson.

WEDNESDAY, SEPTEMBER 6.

The following Papers and Report were read :—

1. *On Possible Relations Between Sun-spots and the Planets.*

By F. J. M. Stratton.

The author discussed the sun-spot material for the years 1874-1909 tabulated to show phase effects due to Venus and Jupiter. The general disagreement of the Venus and Jupiter results, when compared with the agreement found between Venus and Mercury by Dr. Schuster, leads to the general conclusion that the inequalities found are to be traced to the chance incidence of the various sun-spot maxima, and that a considerably longer period must be available before trustworthy results can be obtained.

2. *On the Laws of Solutions.* *By* H. Davies, *B.Sc.*

Ostwald's law does not hold for solutions of binary electrolytes, and empirical relations have been devised by Rudolphi, van't Hoff, Storch, Kohlrausch, &c. The object of this paper is to obtain Rudolphi's and van't Hoff's equations from theoretical considerations and to deduce equations holding for dilute solutions of more complex electrolytes.

Solvents are characterised by strong association. The cause of the association in the case of water is the fact that oxygen has a potential valency of four. Taking this value, chemical formulæ can easily be made up for $(H_2O)n$ where 'n' may be

any integer from 2 upwards. The most probable value of '*n*' for water at ordinary temperatures is 3. While the greater part of any quantity of water consists of $(H_2O)_3$ it is probable that the actual state at any temperature is one of equilibrium between varying amounts of $(H_2O)_3$, $(H_2O)_2$, and H_2O. At the moment of dissociation the single molecule produced is unsaturated and tends to produce dissociation of other water or salt molecules within reach. This seems the proper explanation of the ionisation of solutes. The state of equilibrium existing in water can itself be represented by Ostwald's law derived from the work of Guldberg and Waage, thus

$$\frac{a^2w}{(1-aw)Vw} = Kw \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

The symbols have the meanings usually assigned to '*a*' and 'V.' The law for the solute only, assumed in the same state and occupying the same volume as it actually does in the solution, will be

$$\frac{a^2}{(1-a)V} = K. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

The addition of salt to the solvent will necessarily destroy the state of equilibrium represented by (1) and (2).

The change in equilibrium of water may be proportional to either, (*a*) the amount of salt added, or (*b*) the amount of dissociated salt added.

The change in the value of K for the solute will necessarily be proportional to the amount of dissociated water, as only single molecules, *i.e.* H_2O, are able to attach to themselves the ions from the solute. We may thus put, taking (*a*) above

$$Kw = K'w\frac{1}{V} \text{ and } K = K'\frac{a}{Vw}.$$

As aw will be small, put $1 - aw = 1$; remembering also that Vw is sensibly constant, we can immediately obtain

$$K = \frac{K'}{Vw}\sqrt{K'w\frac{Vw}{V}} = B\frac{1}{\sqrt{V}} = \frac{a^2}{(1-a)V}$$

whence

$$\frac{a^2}{(1-a)\sqrt{V}} = B.$$

This is Rudolphi's law.

If the assumption (*b*) above is used then the change in Kw will be given by

$$Kw = K'w\frac{a}{V},$$

and by the same process as above the final result is

$$\frac{a^3}{(1-a)^2V} = C.$$

This is van't Hoff's equation.

The above equations are thus obtained from theoretical considerations of the law of mass action for both *solvent* and *solute*. The assumption in the theory outlined that is most open to doubt is that involved in equation (1) namely, that water dissociates into two parts.

The most probable value of '*n*' being 3, it is possible that the state of equilibrium is one between $(H_2O)_3$ and three molecules, H_2O. Applying the mass-action law to this case and proceeding as above there results, in place of Rudolphi's equation,

$$\frac{a^2}{(1-a)V^{\frac{2}{3}}} = D,$$

and in place of van't Hoff's equation,

$$\frac{a^{\frac{5}{3}}}{(1-a)V^{\frac{2}{3}}} = E.$$

These two equations do not hold for dilute solutions, so that it seems correct to consider the products of dissociation to be di-hydrol and mono-hydrol at ordinary

temperatures. Applying the same process to the case of electrolytes which give three ions on dissociation, the following equations are obtained corresponding to (*a*) and (*b*).

$$\frac{\alpha^3}{(1-\alpha)V^{1}} = \text{Const.}$$

$$\frac{\alpha^{\frac{3}{2}}}{(1-\alpha)V^{\frac{1}{2}}} = \text{Const.}$$

which should hold for dilute solutions as well as Rudolphi's and van't Hoff's do for binary electrolytes.

3. *Anomalous Dispersion and Solar Phenomena.*
By Professor P. V. Bevan, *M.A.*, *Sc.D.*

If light from a non-uniform source, such as an arc light, be sent through a tube containing non-homogeneous vapour of a metal which can show anomalous dispersion, and then an image of the source be focused on the slit of a spectroscope, an apparent double reversal of certain lines may appear. This phenomenon was observed by the author with potassium vapour first and with other alkali metals later. The explanation of the phenomenon is simple. If the brightest parts of the image formed without the tube of metallic vapour be just above or below the slit of the spectroscope, then when the metal vapour is in the track of the train some of the light of wave length very near that of an absorption line of the metal may be deviated by the metallic vapour sufficiently to fall on the slit. In the most simple case when the vapour acts as a prism with refracting edge horizontal and directed upwards, light of wave length just greater than that of an absorption line is diverted downwards, light of wave length less than that of the absorption line is deviated upwards. When, then, we have the images of the two poles of the arc, one just above and one just below the slit, we may have light from those poles on each side of the absorption line getting into the spectroscope giving bright lines on a darker background, which is formed by the light which has come from elsewhere through the vapour and showing a dark broadened absorption band. This appears to be a double reversal of the line—as a dark line in the position of the actual absorption line always appears between the two bright lines. Various modifications of this appearance can be obtained and similar results to those described by Julius. It seemed as if this phenomenon might have a bearing on solar phenomena and might give some help in the interpretation of spectro-heliographs. The essence of the phenomenon is that a non-uniform source of light should be employed—it is clear that with a point source of light no such double reversal could occur, and that with a uniformly bright source no such phenomenon could occur with vapour acting as a single prism. It is also clear that with any number of masses of vapour of identical nature and a uniform extended source behind them no double reversals could occur. Suppose, however, a uniform plane of luminous matter represents the photosphere and that this is observed normally. In front of this suppose a mass of dense vapour of sodium, for example. This would give broadened absorption lines in light received on a spectroscope. If now above this there is another mass of sodium vapour of less density than the first—this will be transparent to light near the centre of the absorption lines which is absorbed by the first mass. But for this light the refraction index of the vapour may be greater or less than 1, so that light which has come from the parts of the photosphere outside the part shielded by the first mass of vapour may be deviated by the second mass so that it emerges from this normally to the photosphere. We shall have then, when the image of this part of the sun is thrown on the slit of the spectroscope, in addition to the broadened absorption bands, bright light very near the centre of the absorption band and on each side of it. This will appear, therefore, as a double reversal. The conditions for such a phenomenon are simple and, in fact, seem very likely to occur; the effect would be due to numbers of these masses of vapour, and the conditions necessary are simply that the masses of vapour near the photosphere are of greater density than those further away; which is what we should

expect. The effect would be fairly permanent, as is observed in spectro-heliograms, for the detail of the spectro-heliogram is so large that a continually shifting set of masses of vapour would give on the average a similar double reversal until a change of distribution through an enormous volume of the sun's material had taken place. This suggestion is put forward as a possible cause of some of the phenomena observed in spectro-heliograms, which are difficult of interpretation on the more generally accepted theory.

4. *The Use of Diagrams in the Classification of Climates.* *By* Dr. JOHN BALL *and* J. I. CRAIG.

5. *Note on an Unusual Type of Meteor observed at Portsmouth, August* 31, 1911. *By* F. J. M. STRATTON.

The author described the path of a meteor (observed from the end of the pier) moving slowly from the zenith towards the north. The shape of the path (a letter J with arms of 15°, 1½°, 3° approximately) was probably due to foreshortening, accompanied by a slight swerve. The swerve might be traced to spin and resistance, or to unequal heating effects.

6. *Report of the Committee on Electrical Standards.*—See Reports, p. 80.

SECTION B.—CHEMISTRY.

PRESIDENT OF THE SECTION.—PROFESSOR J. WALKER, D.SC., F.R.S.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

Theories of Solutions.

TWENTY-ONE years ago the Chemistry Section of the British Association at its meeting in Leeds was the scene of a great discussion on the nature of solutions. It was my first experience of a British Association meeting, and I well remember the stimulating effect of the lively discussion on all who took part in it. To-day, speaking from the honourable position of President of the Section, I conceive I can do no better than indicate the position of the question at the present time. And this appears to me the more appropriate as our science has had this year to mourn the departure of van't Hoff, the founder of the modern theory of solution, whose name will remain one of the greatest in theoretical chemistry —in time to come, it will, I think, be considered almost the greatest. He had expressed the hope that he might attend this meeting as he did that twenty-one years ago. The hope is not fulfilled: his activity is merged in the final equilibrium of death. But his ideas are part and parcel of the chemical equipment of every one of us, and we know that whatever form the fundamental conceptions of chemistry may assume, the quantitative idea of osmotic pressure will be to the theory of solution what the quantitative idea of the atom is to chemical composition and properties. For I must emphasise the fact that chemistry is essentially a quantitative science, and no chemical theory, no partial chemical theory even, can be successful unless its character is quantitative. To quote the words of Lord Kelvin: 'I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely in your thoughts advanced to the stage of science.'

A general theory of solutions must be applicable to all solutions—to those in which solvent and solute exist in practically mere intermixture, as well to those in which solute and solvent are bound together in what we cannot sharply distinguish from ordinary chemical union. Between these extremes all grades of binding between solvent and solute exist, and it may be well to give a few examples illustrating the various types of solution.

Where no affinity exists between solvent and solute, the solution is practically of the same type as a mixture of two gases which are without chemical action on each other. The solute is merely diluted by the solvent and retains its properties unchanged. An example of this type of solution may be found in the solution of one saturated hydrocarbon in another, say of pentane in hexane. On mixing the two liquids there is no evidence of union between them, the volume of the mixture is practically the sum of the volume of the components, the heat of

solution is practically *nil*, the vapour pressure of each constituent is reduced merely as if by dilution with the other constituent, and so on. That there is some action between the two components even in this extreme case must be admitted, but it may be referred entirely to action of a physical kind, such as one finds on mixing one gas with another at considerable pressures. Action of a chemical nature is absent. If it be said that even saturated hydrocarbons have some chemical affinity for each other, recourse may still be had for examples to mixtures of two inactive elements, say liquid argon and liquid krypton, where chemical affinity is non-existent.

At the other extreme we have such solutions as those of sulphuric acid and water Here there is every physical evidence of chemical union. The volume of the mixture is by no means the sum of the volumes of the components; the amount of heat evolved on mixing is very great; the separate liquids, which are practically non-conductors, yield on mixing a solution which is a good conductor; and so on There is obviously here a great influence of the solvent water on the solute sulphuric acid, and this influence we can only account for by assuming that it is essentially chemical in character.

As the influence in such a case is necessarily reciprocal, then if even one of the constituents of the solution is inactive chemically there can plainly be no action of a chemical nature on mixing. Thus, no matter what solvent we take, it can exercise no action other than that of a physical kind on argon, say, which has been dissolved in it; and, again, if liquid argon is chosen as solvent no substance dissolved in it can be affected by it chemically, and we thus obtain only the properties of a physical mixture. It is convenient therefore to classify liquid solvents according to their chemical activity. The saturated hydrocarbons, which are chemically very inert, and, as their name paraffin implies, little disposed to chemical action of any kind, may be taken as typically inactive solvents, analogous to liquid argon. Water, on the other hand, as its numerous compounds (hydrates) with all kinds of substances testify, may be taken as a typically active solvent. The ordinary organic solvents exhibit intermediate degrees of activity.

For the purpose of illustrating the effect of solvents on a dissolved substance one may conveniently take a coloured substance in a series of colourless solvents. If the substance is unaffected by the solvent, we might reasonably expect the colour of the solution to be the same as the colour of the vapour of the substance at equal concentration. Iodine, for instance, gives rise to the familiar violet vapour. Its solution in carbon disulphide has a colour practically similar, but its solution in alcohol or water is of a brown tint quite different from the other. In the indifferent hydrocarbons and in chloroform the colour is like that in carbon disulphide, in methyl or ethyl alcohol it is brown. We conclude therefore roughly that iodine dissolved in saturated hydrocarbons, in chloroform, carbon tetrachloride and carbon disulphide is little affected by the solvent, whereas in water and the alcohols it is greatly affected, probably by way of combination, since in all the solvents two atoms of iodine seem to be associated in the molecule. That combination between the iodine and the active solvents has really occurred receives confirmation from the behaviour of iodine in dilute solution in glacial acetic acid. If the colour of this solution is observed in the cold it is seen to be brown, resembling in colour the aqueous solution. If the solution be now heated to the boiling-point, the colour changes to pink, which may be taken to indicate that the compound of iodine and acetic acid which is stable at the ordinary temperature becomes to a large extent dissociated at 100°.

Now, as I have said, a general theory of solution must be applicable to all classes of solution, and herein lies the importance of van't Hoff's osmotic pressure theory. It applies equally to mixtures of gases, to mixtures of inert liquids, and to mixtures such as those of sulphuric acid and water; and it has the further advantage that so long as the solutions considered are dilute there are simple relations connecting the osmotic pressure with other easily measurable properties of the solutions. It has been unfortunately the custom to oppose the osmotic pressure theory of solution to the hydrate, or more generally the solvate, theory, in which combination between solute and solvent is assumed. The solvate theory is, in the first place, not a general theory, and in the second place it is perfectly compatible with the osmotic pressure theory. It is in fact with regard

to a general theory of solutions on the same plane as the electrolytic dissociation theory of Arrhenius. This theory of ionisation applies to a certain class of solutions, those, namely, which conduct electricity, and is a welcome and necessary adjunct in accounting for the numerical values of the osmotic pressure found in such solutions. Similarly the hydrate, or more generally the solvate, theory is applicable only to those solutions in which combination between solvent and solute occurs, and will no doubt in time afford valuable information with regard to the osmotic pressure, especially of concentrated solutions in which the affinity between solvent and solute is most evident. It can tell us nothing about solutions in which one, or both, components is inactive, just as the electrolytic dissociation theory can tell us nothing about solutions which do not conduct electricity.

The great practical advantage bequeathed to chemists by the genius of van't Hoff is the assimilation of substances in dilute solution to substances in the gaseous state. Here all substances obey the same physical laws, and a secure basis is offered for calculation connecting measurable physical magnitudes, irrespective of the chemical nature of the substances and of the solvents in which they are dissolved, provided only that the solutions are non-electrolytes. If the solutions are electrolytes, the dissociation theory of Arrhenius, developed independently of the osmotic pressure theory of van't Hoff, gives the necessary complement, and for aqueous solutions offers a simple basis for calculation. Van't Hoff has given to science the numerically definable conception of osmotic pressure; Arrhenius has contributed the numerically definable conception of coefficient of activity of electrolytes in aqueous solution, or what is now called the degree of ionisation.

Of late there has been a tendency in some thermodynamical quarters to belittle the importance of the conception of osmotic pressure. It is quite true that from the mathematical thermodynamical point of view it may be relegated to a second place, and even dispensed with altogether, for it is thermodynamically related to other magnitudes which can be substituted for it. But it may be questioned if without the conception the cultivators of the thermodynamic method would ever have arrived at the results obtained by van't Hoff through osmotic pressure. Van't Hoff was only an amateur of thermodynamics, but the results achieved by him in that field are of lasting importance, and his work and the conception of osmotic pressure have given a great stimulus to the cultivation of thermodynamics to chemistry.

And here we trench on a question on which a certain confusion of thought often exists. To the investigator it is open to choose that one of several equivalent methods or conceptions which best suits his personal idiosyncrasy. To the teacher such a choice is not open. He must choose the method or conception which is most clearly intelligible to students, and is at the same time least likely to lead to misconception. Osmotic pressure is a conception which the chemical student of mediocre mathematical attainments can grasp, and it is not difficult to teach the general elementary theory of dilute solutions by means of it and of reversible cycles without liability to radical error or misconception. I should be sorry on the other hand to try to teach the theory of solutions to ordinary chemical students by means of any thermodynamic function. The two methods are thermodynamically equivalent, and the second is mathematically more elegant and in a way simpler, but it affords less opportunity than the first for the student to submit his methods to any practical check or test, and in nine cases out of ten would lead to error and confusion. The difficulty of the student is not the mathematical one; with the excellent teaching of mathematics now afforded to students of physics and chemistry the mathematical difficulty has practically disappeared--the difficulty lies in critically scrutinising the conditions under which each equation is used is applicable.

Of the mechanism of osmotic pressure we still know nothing, but with the practical measurement of osmotic pressure great advances have been made in recent years. In particular the admirable work of Morse and Frazer is of the first importance in establishing for solutions up to normal concentration the relationship between osmotic pressure and composition, and its variation with the temperature. Much may be anticipated from the continuation of these accurate and valuable researches, the experimental difficulties of which are enormous.

We are indebted to America not only for these researches, and for the voluminous material of H. C. Jones and his collaborators dealing with hydrates in solution, but also to A. A. Noyes and his school for accurate experimental work and for systematic treatment of solutions on the theoretical side. They, and also Van Laar, have shown how solutions not coming within the ordinary range of dilute solutions to which van't Hoff's simple law is applicable, may in some cases at least be made amenable to mathematical treatment. Van't Hoff chose one simplification of the general theory by considering only very dilute solutions, for which very simple laws hold good, just as they do for dilute gases. Even a single gas in the concentrated or compressed form diverges widely from the simple gas laws; much more then may concentrated solutions diverge from the simple osmotic pressure law. The other simplification is to consider solutions of which the components are miscible in all proportions and are without action on each other; and this method has been developed with marked success from the point of view of osmotic pressure and other colligative properties.

The outstanding practical problem in the domain of electrolytic solutions is to show why the strong electrolytes are not subservient to the same laws as govern weak electrolytes. If we apply the general mass-action law of chemistry to the electrically active and inactive parts of a dissolved substance (the ions and un-ionised molecules) as deduced from the conductivities by the rule of Arrhenius, we find that for a binary substance a certain formula connecting concentration and ionisation should be followed, a formula which we know by the name of Ostwald's dilution law. This law seems to be strictly applicable to solutions of feeble electrolytes, but to solutions of strong electrolytes it is altogether without application. Wherein lies the fundamental difference between these two classes of solutions? Two kinds of explanation may be put forward. First, the ionised proportion may not be given accurately for strong electrolytes by the rule of Arrhenius; or second, the strong electrolytes do not obey the otherwise general law of active mass, which states that the activity of a substance is proportional to its concentration. The first mode of explanation has been practically abandoned, for other methods of determining ionisation give values for strong electrolytes in sufficient agreement with the values obtained by the method of Arrhenius. The other explanation is that for some reason the law of active mass is, apparently or in reality, not obeyed by some or all of the substances in a solution of a strong electrolyte. An apparent disobedience to the law of mass-action would, for example, be caused by the formation of complexes such as Na_2Cl_2, or Na_2Cl^+ or $NaCl_2^-$ in a solution of sodium chloride. Mere hydration, *e.g.*, the formation of a complex $NaCl, 2H_2O$, would not affect the mass-action law in dilute solution, and the electrolyte would obey the dilution law in solutions of the concentration usually considered. A somewhat similar explanation, which takes into account the properties of the solvent, is that the ionising power of the solvent water undergoes a noticeable change when the concentration of the ions in it increases beyond a certain limit.

I should wish now to draw attention to a point of view which has not, so far as I am aware, been fully considered. To begin with we may put to ourselves the question: Is it the ions in the solution which are abnormal or is it the non-ionised substance? A simple consideration would point at once to it being the non-ionised portion. We have, for example, in acetic acid a substance which behaves normally, so that the ions H^+ and Ac^-, as well as the undissociated molecule HAc are normal. Similarly in ammonium hydroxide the ions NH_4^+ and $OH-$ as well as the non-ionised NH_3 and NH_4OH all behave normally. When we mix the two solutions there is produced a substance, ammonium acetate, which behaves abnormally. Now, on the assumption that the equilibrium we are now dealing with is

$$NH_4^+ + Ac^- \rightleftarrows NH_4Ac,$$

which of these molecular species is abnormal in the relation between its concentration and its activity? Probably not the ions NH_4^+ and Ac^-, because these were found to act normally in the solutions of acetic acid and ammonia. The presumption is rather that the abnormal substance is the undissociated ammonium acetate, for this occurs only in the abnormal acetate solution, and not in the normal acetic acid and ammonia. This view, that it is the non-

ionised portion of the electrolyte which exhibits abnormal behaviour, and not the ions, has been reached on other grounds by Noyes and others, and I hope in what follows to deduce reasons in its support.

One is apt, because the ions are in general the active constituents of an electrolyte, to lay too much stress on their behaviour in considering the equilibrium in an electrolytic solution. We are justified in attributing the fact that acetic acid is a weak acid, whilst trichloracetic acid is a powerful one, rather to the properties of the un-ionised substances than to the properties of the ions. The divergence of trichloracetic acid from the simple dilution law may similarly be due to an inherent property of the un-ionised acid, a single cause being not improbably at the bottom of both the great tendency to split into ions in water and also the abnormal behaviour towards dilution.

However that may be, I think the following reasoning goes far to show that the non-ionised portion of the electrolyte is that which is primarily abnormal in its behaviour, the ions acting in every way as normal. The dilution formulæ of Ostwald or of van't Hoff is essentially equilibrium formulæ. One side of the equilibrium represents the interaction of the ions to form the non-ionised substance, the other side represents the splitting up of the non-ionised substance into ions. In order to fix our ideas, we may consider a salt which obeys the empirical dilution-formula of van't Hoff. If c_u represents the molar concentration of the un ionised portion, and c_i the molar concentration of each ion, then according to van't Hoff's empirical formula,

$$\frac{c_i^3}{c_u^2} = \text{const.}$$

If the law of mass-action were obeyed we should have, on the other hand, Ostwald's dilution formula,

$$\frac{c_i^2}{c_u} \text{ const.}$$

According to this last formula, the activity of each substance concerned varies directly as its molar concentration, and a normal result is obtained on dilution. According to van't Hoff's formula as stated above, the activity of none of the substances concerned varies directly as its concentration; but since the constancy of the expression is the only test of its accuracy, there are obviously other methods of stating the relation which will throw the abnormal behaviour either on the ions or on the non ionised substance. Thus, if we write the equivalent form

$$\sqrt{\frac{c_i^3}{c_u^2}} = \text{const., or } \frac{c_i^{1.5}}{c_u} \text{ const.,}$$

the un-ionised substance is here represented as behaving normally, and the ions abnormally; whilst if we write the formula in the form

$$\frac{c_i^2}{c_u^{1.33}} = \text{const.,}$$

the ions are represented as behaving normally, and the non-ionised substance abnormally. Now it is very important that a choice should be made amongst these three expressions, all equivalent amongst themselves so far as the mere constancy of the expression is concerned, as tested by measurements of electrolytic conductivity. Looked at from the kinetic point of view we have in the first form,

$$\frac{dx}{dt} = kc_i^3$$

$$-\frac{dx}{dt} = k'c_u^2,$$

both direct and reverse actions abnormal. In the second form, we have

$$\frac{dx}{dt} = kc_i^{1.5}$$

$$-\frac{dx}{dt} = k'c_u.$$

the ionisation being normal, the recombination abnormal. And in the third form we have

$$\frac{dx}{dt} = kc_i^2$$

$$-\frac{dx}{dt} = k'c_u^{1\cdot 33},$$

the ionisation being abnormal and the recombination normal.

Now, if it were possible to measure directly the velocity of either ionisation or recombination, we should at once be able to select the equilibrium formula which was really applicable. Unfortunately such velocities are so high as to be beyond our powers of measurement. Yet it seems possible to seek and obtain an answer from reaction velocities which are measurable. One assumption must be made, but it seems to me so inherently probable that few will hesitate to make it. It is this, if a substance in a given solution has normal activity with respect to one reaction, it has normal activity with respect to all reactions in which it can take part in that given solution. Similarly, if a substance in a given solution exhibits abnormal activity with respect to one reaction, it will exhibit abnormal activity with respect to all.

Granting this assumption, we have then to find a reaction in which either the ionised or un-ionised portion of an abnormal electrolyte is converted into a third substance with measurable velocity. Such a reaction exists in the transformation of ammonium cyanate into urea in aqueous and aqueous-alcoholic solutions, which was investigated some years ago by myself and my collaborators, and found to proceed at rates which could easily be followed experimentally. First of all comes the question : Is the urea formed directly from the ions or from the un-ionised cyanate? As Wegscheider pointed out, it is impossible from reaction-velocity alone to determine which portion passes directly into urea, if the velocities of ionisation and recombination are infinitely greater than that of the urea-formation, as is undoubtedly the case. Other circumstances make it highly probable that the ions are the active participants in the transformation, but we may leave the question open, and discuss the results on both assumptions.

Suppose, first, that the un-ionised cyanate is transformed directly into urea. Then we have the successive reactions

$$NH_4^{\cdot}+CNO' \rightleftarrows NH_4CNO \longrightarrow CO(NH_2)_2.$$

The slight reverse transformation of urea into cyanate may for the present purpose be neglected, as it in no way influences the reasoning to be employed.

If the un-ionised substance behaves normally, then the conversion of the ammonium cyanate into urea, when referred to the un-ionised substance, will appear unimolecular and obey the law of mass-action : when referred to the ionised substance it will not appear to be bimolecular and will not obey the law of mass-action.

Suppose, now, that the direct formation of the urea is from the ions. Then we are dealing with the actions

$$NH_4CNO \rightleftarrows NH_4^{\cdot}+CNO' \rightarrow CO(NH_2)_2.$$

Again, let us assume the un-ionised substance to be normal. Once more, if the transformation is referred to the non-ionised substance it will appear as monomolecular; when referred to the ionised substance it will not appear as bimolecular, as it should if the mass-action law were obeyed..

It is a matter of indifference, then, so far as the point with which we are dealing is concerned, whether the ionised or the non-ionised cyanate is transformed directly into urea. If the non-ionised cyanate behaves normally the action when referred to it will in either case appear to be strictly monomolecular.

If the ionised cyanate, on the other hand, behaves normally, the reaction when referred to it will be bimolecular and normal; when referred to the non-ionised cyanate it will not be monomolecular, and therefore will be abnormal.

The actual experiments show that whether water or a mixture of water and alcohol be taken as solvent, the reaction when referred to the ions is strictly bimolecular; when referred to the non-ionised substance it is not monomolecular,

i.e. proportional to c_u, but is rather proportional to a power of c_u other than the first, namely $c_u^{1\cdot 4}$.

This is, to my mind, a very strong piece of evidence that in the case of the abnormal electrolyte, ammonium cyanate, the abnormality of the ionisation equilibrium is to be attributed entirely to the non-ionised portion. But ammonium cyanate differs in no respect, with regard to its electrolytic conductivity, from the hundreds of other abnormal binary electrolytes with univalent ions; and I am therefore disposed to conclude that it is to the non-ionised portion in general of these electrolytes that the abnormality is to be attributed.

As I have already indicated, this conclusion is not altogether novel, but in my opinion it has not been sufficiently emphasised. Even in discussions where it is formally admitted that the divergence from the dilution law may be due to the non-ionised portion, yet the argument is almost invariably conducted so as to throw the whole responsibility on the ions. The point which ought to be made clear is whether the constant k of the equation

$$\frac{dx}{dt} = kc_i^2,$$

or the constant k' of the reverse equation

$$-\frac{dx}{dt} = k'c_u,$$

is really constant. If the former, then the ions are truly normal, and primary explanations of the abnormality of the strong electrolytes can scarcely be sought in high total ionic concentrations and the like, though a connection between the two no doubt exists, both being determined by the same cause.

In my illustration I have assumed that there holds good a dilution law of the kind given by Storch, of which van't Hoff's dilution law is a particular case. Here the active mass is represented as a power of the concentration other than the first power. The argument I have used is altogether independent of this special assumption; the active mass of the abnormal substance may be any function of its concentration, and the same conclusion will be reached.

Nernst's principle of the constant ionic solubility product affords additional evidence that the ions act normally in solution. In deducing this principle it is generally assumed that it is the constant solubility of the non-ionised salt that determines the final equilibrium. This assumption, though convenient, is not necessary. The equilibrium is a closed one, thus:—

$$\begin{tikzcd}
 & \text{Ions} \arrow[dl, shift left] \arrow[dr, shift left] & \\
\text{Solid Salt} \arrow[ur, shift left] \arrow[rr, shift left] & & \text{Non-ionised Salt} \arrow[ll, shift left] \arrow[ul, shift left]
\end{tikzcd}$$

The solid is not only in equilibrium with the non-ionised salt but also with the ions. Now, in the deduction of the change of solubility caused by the addition of a substance having one ion in common with the original electrolyte the mass-action law for ionisation is assumed. This is of course justified when we deal with feeble electrolytes, but in the case of salts and strong acids which do not follow the mass-action law the experiments are found still to be in harmony with the theoretical deductions. This is not only so when the two substances in solution are both abnormal, but also when one is abnormal and the other normal, no matter which is used to produce the saturated solution. In fact, the principle of the constant ionic solubility product may be employed with equal success to calculate the effect on the solubility of one electrolyte of the addition of another electrolyte with a common ion, whether both electrolytes are normal, both abnormal, or whether one is normal and the other abnormal. At first sight, this apparent obedience of abnormal electrolytes to the mass-action law seems strange, but a little consideration shows that if it is only the non-ionised portion of a

salt that is truly abnormal, the theoretical result is to be expected. Suppose that the ions do behave normally in the ionisation, then they must also act with normal active mass with reference to the solid, with which they may be regarded as in direct equilibrium according to the closed scheme referred to above. A change, then, in the concentration of any one of the ions, brought about by the addition of a foreign salt with that ion, will necessarily bring about the change in solubility of the salt calculated from the mass-action law, so far at least as experiment can tell us, for any variation from theory is caused by the change in the nature of the solvent due to the addition of the foreign substance. We ought, then, on the assumption that the ions behave normally, to expect that the principle of the constant solubility product would yield results of the same degree of accuracy in dilute solutions whether the electrolytes considered were normal or abnormal. This, as I have said, is actually the case.

To put the whole matter briefly, in the equilibrium between electrolytes agreement will be obtained between theory and experiment whether we use the mass-action law, or an empirical law such as van't Hoff's dilution formula, provided only that we attribute the abnormality to the non-ionised portion of the electrolyte. Thus we can deduce the ordinary formulæ for hydrolysis or for isohydric solutions as readily for abnormal as for normal electrolytes, and find the most satisfactory agreement with experiment in both cases.

By this one simple assumption, then, for which I have offered some direct justification, it is possible to find a basis for calculation with abnormal electrolytes. The problem of *why* certain electrolytes should be normal and others abnormal is, of course, in no way touched by this assumption. That is a matter for further investigation and research.

Another great desideratum of the theory of solutions is to find a general basis for the calculation of hydrates. The present position of the theory of hydrates in solution may perhaps most aptly be compared with the theory of electrolytic dissociation for solvents other than water. That hydrates exist in some aqueous solutions is undoubted, but no general rule or method exists for determining what the hydrates are and in what proportions they exist. Similarly the theory of electrolytic dissociation applied to other than aqueous solutions affords no general means of determining what the ions are and how great is the degree of ionisation. It is only for aqueous solutions that Arrhenius was able to give a practically realisable definition of degree of ionisation, and it is on this definition that the whole effective work on aqueous electrolytes is based; and until some general practically applicable principle of a similar character is attained for hydrates, the work done on that subject, however interesting and important it may be in itself, must necessarily be of an isolated character.

Arrhenius did not originate the doctrine of electrolytic dissociation or free ions: that was enunciated in 1857 by Clausius, and remained relatively barren. What he did was to introduce measurable quantities into the doctrine, and to show its simple quantitative applicability to aqueous solutions; immediately it became fertile. And as soon as a simple quantitative principle is developed for hydrates in solution, that doctrine will become fertile also.

It is surely now time that all the irrelevant and intemperate things that have been said and written by supporters of the osmotic pressure and electrolytic dissociation theories on the one hand, and by those of the hydrate theory on the other, should be forgotten. Far from being irreconcilable, the theories are complementary, and workers may, each according to his proclivity, pursue a useful course in following either. One type of mind finds satisfaction in using a handy tool to obtain practical results; another delights only in probing the ultimate nature of the material with which he works. For the progress of science both types are necessary—the man who determines exact atomic weights as well as the man who speculates upon the nature of the atoms. That the lack of knowledge as to what the exact nature and mechanism of osmotic pressure is, should prevent accurate experimental work being done on it, or interfere with its use in theoretical reasoning, is equally ridiculous with the proposition that because in the theory of osmotic pressure we have a good quantitative tool for the investigation of solutions, therefore we should abandon altogether the problem of its nature.

The fundamental ideas of a science are the gift to that science of the few

great masters; the many journeymen investigators may be trusted to utilise them according to their abilities. Having once given his great principles to the world, van't Hoff remained practically a spectator of their development; but by his single act he provided generations of chemists with useful and profitable fields for their labour.

The following Papers and Report were then read :—

1. *The Diffusion of Gases through Water.* *By* Professor CARL BARUS.

Although relatively few measurements of the diffusion of gases through liquids have been made, the subject is one of great chemical interest, inasmuch as with given coefficients of diffusion the *virtual* viscosity of the medium through which a single molecule of the gas transpires through the intermolecular pores of the liquid may be computed. Hence for a variety of liquids and gases the data should throw light on intermolecular structure.

The method consisted in finding the temperature pressure conditions of the flotation, at a given level of a cylindrical cartesian diver, in which the gas to be examined had been imprisoned. It is remarkable both for its extreme simplicity and its astonishing accuracy, provided a room of constant temperature is at hand; for the few milligrams of gas contained may be weighed with the same relative accuracy with which absolute temperature and pressure may be measured.

The finite and differential equations of the phenomenon (the latter being expressible in terms of the density of the diffusing gas, if not simple) were discussed and lantern-slides exhibited showing details of the apparatus, the mass-time graphs throughout a period of months for the interdiffusion of air-air, hydrogen-hydrogen, air hydrogen, hydrogen-air, and oxygen hydrogen, through water, and the constants for the first two cases. Whereas the graphs for a single gas are linear, those for pairs of gases are of indefinite variety, and the very curious result of a gas apparently diffusing against the obvious pressure gradient is frequently met with. Such anomalous results are explained in terms of the partial pressures of the constituents of the imprisoned impure gas.

2. *The Present Position of Electric Steel Melting.* *By* Professor ANDREW McWILLIAM, *A.R.S.M.*, *M.Met.*—See Reports, p. 261.

3. *The Compressibility of Mercury.* *By* Dr. WM. C. McC. LEWIS.

It has been shown recently[1] that the following expression holds within the limit of error for the majority of normal liquids :—

$$L = \frac{T\alpha}{\rho\beta},$$

where L = the latest heat of vaporisation of the liquid, T = abs. temp., α = coefficient of expansion of the liquid, β = compressibility of the liquid, and ρ = density of the liquid.

In the case of mercury, however, the discrepancy between observed and calculated L is great; and as both L and α are known with considerable accuracy, it seemed likely that the cause of the discrepancy was to be found in the usually accepted value of β. L is calculated from the vapour-pressure data given by M. Knudsen[2]; the values of α are those given by Callendar and Moss.[3] At 20° C. the calculated value of β is $(1{\cdot}30 \pm 0{\cdot}02) \times 10^{-6}$ per kilo/cm². The most recently determined value of β, that of P. Bridgman,[4] is $3{\cdot}70 \times 10^{-6}$ on

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[1] *Phil. Mag.*, July 1911.

[2] *Ann. d. Physik.*, **29**, 179 (1909).

[3] *Proc. Roy. Soc.*, A. **84**, 595, 1911 (Abstract); *cf. Trans.*, i., 1911.

[4] *Proc. Amer. Acad.*, **44**, 255 (1909).

the same units. As possible sources of error in experimental determination may be suggested :—

(1) Effects produced by a layer of absorbed air or moisture, or both, between the mercury and the walls of the vessel;
(2) That the liquid (molasses mixture) into which the piston was dipped before insertion in the mercury is not completely removed; and
(3) The unavoidable slip of the mercury past the piston.

All these effects act in the same direction; *i.e.*, they give rise to too great a volume decrease, that is, to too high values of the compressibility.

4. *The Chemistry of the Glutaconic Acids.* *By* Dr. J. F. Thorpe, *F.R.S.*

5. *The Influence of Constitution on the Molecular Volumes of Organic Compounds at the Boiling Point.* *By* G. Le Bas.

6. *The Influence of Substituents on Reaction Velocities.*
By Professor R. Wegscheider.

7. *Report on the Influence of Carbon and other Elements on the Corrosion of Steel.*—See Reports, p. 83.

FRIDAY, SEPTEMBER 1.

The following Papers and Reports were read :—

1. *Discussion on Indicators and Colour.*

(i) *The Application of Methyl Orange for the Determination of the Affinity Constants of Weak Acids and Bases, with a Discussion of the Errors.* *By* Dr. V. H. Veley, *F.R.S.*

A brief account was given of the use of indicators, especially methyl orange, for determining the affinity value of acids, as also of bases by the hydrolysis values of their hydrochlorides. The advantages, limitations, and defects of the method proposed were discussed in detail, and especial stress was laid upon the fact that the method, though simple in its execution, is not intended to supersede other methods of greater accuracy, available under like conditions. The data of the hydrolysis, and affinity values deduced therefrom, are independent of the more or less conflicting theories, namely, the ionic and chromophoric, of indicators. Exception was more particularly taken to any correction of the experimental results for the hydrogen ion concentration of the solutions, such correction being based upon theoretical speculations based upon the former theory, which has not met with universal acceptance.

(ii) *The Sensitiveness of Indicators.* *By* H. T. Tizard.
See Reports, p. 268.

2. *Report on Dynamic Isomerism.*—See Reports, p. 91.

3. *The Ultra-Violet Absorption Spectra of the Vapours of various Organic Substances compared with the Absorption of these Substances in Solution and in Thin Films.* *By* J. E. PURVIS.

Pyridine, a-picoline, 2 : 6-lutidine, 2 : 4-lutidine, 2 : 4 : 6-trimethyl pyridine and piperidine.—Pyridine vapour under varying conditions of temperature and pressure shows a considerable number of narrow bands which can be arranged in groups having similar appearances and regular differences in their wave lengths; a-picoline under similar conditions shows a much less number of bands, but some of them are not unlike those of pyridine. Both these substances also exhibit a strong absorption band in the ultra-violet regions and more refrangible than the narrow bands. The vapours of the two lutidines and of trimethyl pyridine do not show any narrow bands; but each shows a strong absorption band analogous to that in pyridine and a picoline. The vapour of piperidine shows a number of bands which can be divided into groups and which are unlike those of pyridine.

Nicotine, Coniine, and Quinoline.—The vapours of these three substances exhibit none of the series of narrow bands found in the vapour of pyridine. Solutions of nicotine show a band analogous to that of pyridine; solutions of coniine show no band, a result similar to that of piperidine solutions; and quinoline has one large band as vapour, and three solution bands, as first observed by Hartley.

Furan, furaldehyde, thiophen, and pyrrole.—Furan vapour shows some narrow absorption bands; as does the vapour of furaldehyde, but they are different from those of furan; the vapours of thiophen and pyrrole show a few bands, two of which are comparable with two in the vapours of furan and furaldehyde. Solutions of furan, thiophen, and pyrrole show no absorption bands: but solutions of furaldehyde show a strong band in the ultra violet. Thin films of these three substances show no selective absorption.

Aniline, mono- and di-methyl aniline, mono- and di-ethylaniline, o- *and* m-*toluidine,* o-3-*xylidine,* m-2-*xylidine, mesidine, and benzylamine.*—Aniline vapour shows a considerable number of bands which can be divided into similar groups; whilst the vapours of the homologues show none of these narrow bands. In the solutions, the single band of aniline is considerably reduced in persistency when the hydrogen of the amino-group of aniline is replaced by alkyl groups; and when the hydrogen of the nucleus is replaced by alkyl groups, the band becomes large and more persistent.

Chloro- and bromo-benzenes.—Both vapours show a considerable number of absorption bands, which have general relationships amongst themselves, both in structure and in differences of wave lengths. Each group of bands in the bromobenzene vapour is shifted more towards the red end of the spectrum than the corresponding groups of the chloro-benzenes. Solutions of the substances show seven wide diffuse bands which are comparable in appearance, and only differ in position dependent upon differences in the molecular weights. And very thin films exhibit seven wide diffuse bands comparable with the solution bands: they differ in position according to differences of molecular weights.

The author is engaged in a comparative study of the *o*- and *m*-dichloro- and dibromobenzenes, and of *o*- and *m*-chloro and bromotoluenes. The results show that the vapours of these substances have a number of narrow bands, but fewer than those observed in the chloro- and bromobenzenes: and that their solutions and thin films show none of these narrow bands, but that they are replaced by several wide diffuse bands which differ chiefly in their position dependent upon the molecular weights. The orientation in the *o*- and *m*-compounds is also a factor both in the vapours, in the solutions, and in the thin films.

These results may be discussed from a consideration of the movements of the atoms of the molecules being influenced by their nature, weight, type, and orientation. The extent of the free path as well as the impacts of symmetrically and unsymmetrically oriented molecules, and possibly the influence of the radiant energy of the source of light, are also to be considered. The vapour molecules have greater freedom of movement, and a considerable number of bands are produced; unless, as in the case of the pyridine and aniline derivatives, the unsymmetrical orientation of the atoms of the molecules implies a dislocation in the vibrations so that the rhythmical oscillation is destroyed. In solution the solvent

acts partly as a constraint on the vibrations and partly as a barrier to the number of encounters and partly as an absorbent of the radiant energy, so that the narrow bands of the vapours are usually replaced by wide diffuse bands. In very thin films the movements of the molecules are further restricted as a consequence of the closer packing: but the selective absorption is not unlike that of the solutions; the chief difference being that the bands of the thin films are shifted more towards the less refrangible regions.

4. *Absorption Spectra and Refractive Power of Metallic Vapours.*

By Professor P. V. Bevan, *M.A., Sc.D.*

More attention has lately been devoted to the absorption spectra of metals for various reasons. The importance of the subject from the point of view of astrophysics has been more generally recognised, and also the interest of the phenomena from their character as a pure physical or chemical manifestation of the properties of the molecule or atom. Research in these lines has been greatly stimulated by the beautiful results obtained by R. W. Wood in the case of sodium. His observation of forty-eight of the lines of the principal series for sodium was a remarkable extension of our knowledge of series spectra. My own work in this part of the subject has been simply to extend the method of Wood to the other alkali metals, and to find that in the cases of all of them a similar series can be obtained. These series, the first and second members of which are the familiar lines characteristic of the alkali metals, all appear as absorption lines when white light is passed through the vapours of the metals. With increase of density of the metal more lines come into view, and to obtain a much larger number than have been measured yet requires only greater dispersion in the Spectrograph used. The lines form a series getting closer and closer together at the ultra-violet end of the spectrum, and more powerful instruments are required to resolve more of them. (Slides shown to indicate the character of the spectra.) Up to the present I have been able to extend the series to 41 members in the case of lithium, 24 for potassium, 30 for rubidium, and 31 for cæsium. When it is remembered that in the case of emission spectra only 7 members of the series were known for sodium, 9 for potassium, 5 for rubidium, 9 for cæsium, and 9 for lithium, it can be seen what an extension of the field has been made by the new method. Wood has also opened a wide field in the relationship between these absorption spectra and other banded spectra which appear with them and fluorescent and magnetic rotation spectra. The complexity of these spectra is very great, and no more can be said than to refer those who are interested in the matter to Wood's great paper on sodium spectra.

The question of applicability to the series spectra of formulæ based on the work of Rydberg is of great interest. A great deal of work has been done in this region by Hicks and Ritz especially, and formulæ have been proposed which express the series and the relations between different series with the use of surprisingly few constants.

The phenomena of dispersion in metallic vapours is of great interest because of their bearing on optical theory and on the views we can derive as to the nature of the atom and the vibrating systems that give rise to spectrum lines. Anomalous dispersion has been observed in the cases of all the alkali metals and several others.

I can only refer to the work of Kundt, Becquerel, Ebert, Schön, Puccianti, Luminor, and Pringsheim in this region. The later work of Wood and others has given us a quantitative measure of the effects, and from these we can gain some information as to the nature of atoms. A great deal of work has been done on the dispersion in ordinary gases, but in these cases the region investigated is far from the absorption lines. The case of hydrogen is different, for Ladenburg has shown that when hydrogen is itself excited by an electric discharge it can produce anomalous dispersion effects. This brings it into relation with the alkaline metals, and is strongly in support of the theory that specialised molecules take part in optical phenomena. The difficulty in experiments with metallic vapours is to arrive at absolute measurements; my own work has been concerned with relative measurements at different lines of the principal series.

The anomalous dispersion effect takes place at all these lines. Absolute measurements have been made by inference methods by Wood and St. Loria in the case of sodium, and from these, if we know the density of the vapour, we can obtain an estimate of the number of electrons taking part in the effect on light, assuming the dispersion theory of Drude to hold. The fact that Drude's theory gives excellent agreement with experiment for all relative measurements is strong evidence in support of its main correctness. Loria obtained the result from his experiments with sodium vapour at 380° C. that the ratio of the total number of atoms engaged in optical effects to the whole number of atoms was 400 : 3. I calculated from Wood's experiments at 644° C. that the same ratio was about 12 : 1. This depends on a very rough estimate of the density of the vapour, but is of the right order. From measurements at other lines it appears that each line of the series is probably due to a special set of atoms, so that there are indications that the complexity of a spectrum is not due to complexity of each individual atom, but to differences actually existent in the atom. This view has been in the minds of physicists for some time, and there is hope that work on the lines described may enable us to find out something of the nature of the differences. A good deal of evidence of other kinds leads in the same direction—the Zeeman effect, the magnetic rotation of the plane of polarisation, and so on; but this is not the occasion to discuss these problems.

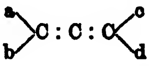
An interesting method of preparing rubidium and cæsium may be mentioned. Hackspill found they could be prepared by heating the chlorides with calcium. I found in some early experiments that the metals could be obtained by heating the chlorides with sodium, and later that if lithium be used the vapours are obtained practically pure owing to the much greater temperature required for vaporising lithium than for the other metals.

5. *Optically Active Substances which contain no Asymmetric Atom in the Molecule. By* Professor WILLIAM HENRY PERKIN, *F.R.S., and* Professor WILLIAM JACKSON POPE, *F.R.S.*

Whilst pointing out the relation between molecular configuration and optical activity van't Hoff clearly indicated that substances which exhibit optical activity in solution do not necessarily contain an asymmetric atom in the molecule; whilst he pointed out that optical activity results from enantiomorphism of molecular configuration and showed that in general the latter type of enantiomorphism is recognisable by the presence of an asymmetric carbon atom in the graphic formula, he also made it quite clear that cases of optical activity might arise amongst compounds which contain no asymmetric carbon atom in the molecule.

It is now known that a substance may exhibit optical activity in the amorphous or dissolved condition if its molecule contains an atom of quinquevalent nitrogen or phosphorus or of tetravalent sulphur, selenium, silicon, or tin. The most general case of optical activity distinguished by van't Hoff, that exhibited by a substance of enantiomorphous molecular configuration, but of which the molecule contains no asymmetric atom, has, however, not been realised until quite recently.

Van't Hoff referred to substances of the general constitution :—

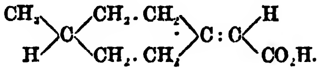


$${}^{a}_{b}\!>\!\mathrm{C}:\mathrm{C}:\mathrm{C}\!<^{c}_{d}$$

as being capable of existing in two enantiomorphously related molecular configurations. The symmetrical dimethylallene, CHMe : C : CHMe, which belongs to this class, should exist in two enantiomorphously related, and hence optically active, isomerides; although this substance has been prepared it is obvious that experimental difficulties will render difficult its resolution into optically active components.

As the most general case of optical activity is of profound theoretical importance, we have for a number of years devoted ourselves to its realisation. After

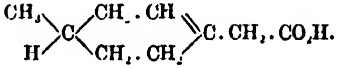
a considerable amount of preliminary experimental work we decided that the most suitable compound belonging to this particular class is the 1-methyl*cyclo*hexylidene-4-acetic acid :—



$$\begin{array}{l}CH_3\\H\end{array}\!\!>C<\!\!\begin{array}{l}CH_2.CH_2\\CH_2.CH_2\end{array}\!\!>C:C<\!\!\begin{array}{l}H\\CO_2H.\end{array}$$

The reason why this decision was arrived at is that, whilst 1-methyl*cyclo*hexylidene-4-acetic acid contains no asymmetric atom in the molecule, but nevertheless possesses an enantiomorphous molecular configuration, it appeared possible to devise a method for its synthesis : and since it should be distinctly acidic in character it would be expected that its resolution could be effected by crystallisation with an optically active alkaloid.

We therefore devised a process for the synthesis of this acid.[1] Curiously enough, however, whilst we were occupied with this work, Marckwald and Meth[2] indicated that they had also decided to prepare 1-methyl*cyclo*hexylidene-4-acetic acid and to resolve it into optically active components in order to realise the most general case of optical activity, and described the method by means of which they had synthesised and resolved the substance. The methods of synthesis adopted by Marckwald and Meth, on the one hand, and by ourselves on the other, were quite different and yielded quite different products; our acid melted at 66°, whilst that of Marckwald and Meth melted at 40-41°. We were, however, convinced that our method of synthesis yielded the compound of the constitution stated above and that Marckwald and Meth's acid was the isomeric 1-methyl Δ ^{1} *cyclo*hexene 4 acetic acid of the constitution :—



$$\begin{array}{l}CH_3\\H\end{array}\!\!>C<\!\!\begin{array}{l}CH_2.CH\\CH_2.CH_2\end{array}\!\!\geqslant C.CH_2.CO_2H.$$

An acid of the above constitution obviously contains an asymmetric carbon atom and hence should be resolvable, as Marckwald and Meth found, into optically active components in the same way as large numbers of similarly constituted substances. We therefore disputed Marckwald and Meth's contention that their acid was 1-methyl*cyclo*hexylidene-4-acetic acid,[3] and in reply these authors[4] produced further evidence in support of their view; they had in this the support of Wallach, who was then of opinion that their acid had the constitution which they had assigned to it.

The difference of opinion briefly referred to above gave rise to a long controversy and led to an extended series of experimental investigations.[5] The final result of this work was to prove conclusively that the original view taken by us was correct; the acid melting at 66° is the true 1-methyl*cyclo*hexylidene-4-acetic acid, whilst the acid melting at 40-41°, which Marckwald and Meth supposed to be the latter acid, is the 1-methyl-Δ^3-*cyclo*hexene-4-acetic acid, the graphic formula of which contains an asymmetric carbon atom.

After our original view had been shown to be correct an improved method of preparing our acid was devised and its resolution effected[6] by crystallisation with brucine. The d- and 1-isomerides of 1-methyl-*cyclo*hexylidene-4-acetic acid were ultimately obtained of the specific rotatory power $[\alpha]_D$ + or $-81{\cdot}1°$; each optically component melted at $52°{\cdot}5$—53° and the externally compensated mixture of the two at 66°.

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[1] Perkin and Pope, *Trans. Chem. Soc.*, 1908, **93**, 1075.

[2] *Ber.*, 1906, **39**, 1171.

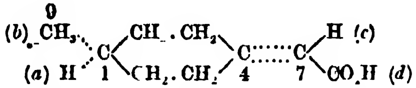
[3] *Proc. Chem. Soc.*, 1906, **22**, 107.

[4] *Ber.*, 1906, **39**, 2404.

[5] Marckwald and Meth, *Ber.*, 1906, **39**, 1171, 2035, 2404; Wallach, *Annalen*, 1907, **318**, 311 ; 1909, **365**, 255; Perkin and Pope, *Trans.*, 1908, **93**, 1075; Harding, Perkin and Haworth, *Trans.*, 1908, **93**, 1943; Hope and Perkin, *Trans.*, 1909, **95**, 1360.

[6] Perkin, Pope, and Wallach, *Trans.*, 1909, **95**, 1789.

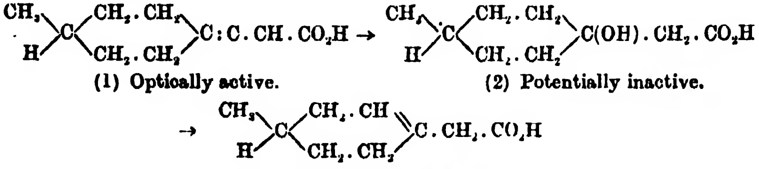
The configuration of 1-methyl*cyclo*hexylidene-4-acetic acid may be represented in the following manner:—



in which those bonds represented by unbroken lines all lie in one plane, and those represented by broken lines lie in a plane perpendicular to the first; if the continuous lines represent bonds which lie in the horizontal plane of the paper, the broken lines stand for bonds which lie in the vertical plane passing through the carbon atoms numbered 1, 4, and 7. It will now be seen that the plane of the paper which contains the continuous line bonds is not a plane of symmetry of the solid configuration, because the hydrogen atom marked (*a*), which lies outside that plane, is not repeated on the other side of the plane, the symmetrical position being occupied by the methyl group (*b*). Similarly the vertical plane remarked above is not a plane of symmetry of the configuration, because the groups (*c*) and (*d*), of different compositions, occupy symmetrical positions on the two sides of the plane. In the same way it can be shown that no other plane is a plane of symmetry of the configuration as above represented. Further, no directions can be distinguished as axes of symmetry of the solid configuration, nor can any point be located within it as a centre of symmetry. It is thus seen that when a highly symmetrical configuration is attributed to methane derivatives the configuration assignable to 1-methyl*cyclo*hexylidene-4-acetic acid possesses neither planes, axes, nor a centre of symmetry. The absence of all these elements of symmetry is more than is requisite to determine the enantiomorphism of the configuration.

In order to distinguish substances of enantiomorphous molecular configuration which contain no asymmetric atom in the molecule from those in which an asymmetric atom is present, it is convenient to describe the former as 'centroasymmetric.' The discovery of optically active centroasymmetric compounds opens up a wide field of stereochemical inquiry, part of which we have recently explored.

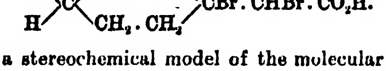
Thus, the centroasymmetric 1-methyl*cyclo*hexylidene-4-acetic acids can be converted into the 1-methyl-Δ^3-*cyclo*hexene-4-acetic acid of Marckwald and Meth, in which an asymmetric carbon atom is present; it became important to perform this conversion upon optically active material in order to ascertain whether optical inversion attends the change. On heating laevo-1-methyl*cyclo*hexylidene-4-acetic acid with water, sulphuric acid and alcohol, the required conversion takes place, but the product, the acid of Marckwald and Meth, is optically inactive. It is concluded that the change occurs with formation of a saturated hydroxy-acid as an intermediate product, in accordance with the following scheme:—



(1) Optically active. (2) Potentially inactive.

(3) Externally compensated.

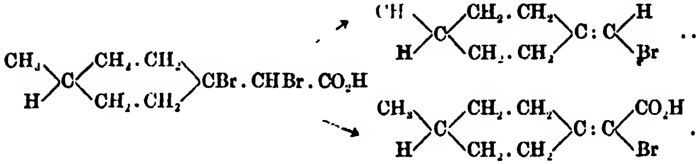
More importance attaches to the addition of bromine to the unsaturated centroasymmetric acid, a reaction which results in the formation of a saturated acid of the constitution,



The inspection of a stereochemical model of the molecular configuration of the unsaturated acid shows that the two atoms of bromine may be taken up in two

distinct ways, each resulting in a configuration which contains an asymmetric carbon atom. The bromine atoms may become attached at the same side of the model as the methyl group or at the other side. In accordance with this prediction it is found that the externally compensated, dextro-and laevo-1-methyl*cyclo*hexylidene-4-acetic acids each yield two dibromides, which may be distinguished as the α- and β-isomerides. Those obtained from the active acids are themselves optically active, and on mixing them in equal quantities the externally compensated dibromides obtained from the externally compensated acids are produced. No evidence of any optical inversion was obtained from the study of the bromination products.

The α- and β-dibromides just referred to undergo two simple reactions which reconvert them into compounds of the centroasymmetric type. On warming with sodium carbonate solution they lose carbon dioxide and hydrogen bromide, yielding 1-methyl-4-bromomethylene*cyclo*hexane (1), and when heated with 50 per cent. potash they lose hydrogen bromide alone, giving 1-methyl*cyclo*hexylidene-4-bromoacetic acid (2), thus :—



$$\begin{matrix}CH_3\\H\end{matrix}\!>\!C\!<\!\begin{matrix}CH_2.CH_2\\CH_2.CH_2\end{matrix}\!>\!CBr.CHBr.CO_2H \begin{matrix}\nearrow \begin{matrix}CH_3\\H\end{matrix}\!>\!C\!<\!\begin{matrix}CH_2.CH_2\\CH_2.CH_2\end{matrix}\!>\!C:C\!<\!\begin{matrix}H\\Br\end{matrix} \quad \ldots (1)\\ \searrow \begin{matrix}CH_3\\H\end{matrix}\!>\!C\!<\!\begin{matrix}CH_2.CH_2\\CH_2.CH_2\end{matrix}\!>\!C:C\!<\!\begin{matrix}CO_2H\\Br\end{matrix} \quad \ldots (2)\end{matrix}$$

Both these reactions proceed quantitatively, and when carried out with the pure optically active α- or β-dibromides, yield pure optically active centroasymmetric products.

The bromo-hydrocarbon and the bromo-acid (1) and (2) readily combine with chlorine, yielding dichlorides which contain an asymmetric carbon atom in the molecule. When these compounds are prepared from optically active materials they are themselves optically active; each of course would be expected to consist of a mixture of two isomerides related as are the α- and β-dibromides.

It is very noteworthy that the long series of changes to which the centroasymmetric optically active 1-methyl*cyclo*hexylidene-4-acetic acids have now been subjected yield products which do, or do not, exhibit optical activity precisely in accordance with anticipations drawn from the study of the solid models representing the configurations of the substances concerned. The conviction that the structural formulæ assigned to chemical substances imitate with considerable approximation to truth the real nature of molecular constitution was appreciably deepened by the introduction of the theory of the configuration of methane derivatives by van't Hoff and Le Bel; the development of the theory by Wislicenus, so as to embrace the configuration of ethylene derivatives, and by von Baeyer, in connection with polymethylene derivatives, has strengthened the view that the constitutional formulæ of organic chemistry represent very closely the actual atomic arrangement of molecular complexes. The considerations which led to the work described in the present paper involved, as has been seen, the development of the original simple conception of the space configuration of methyl and ethylene derivatives to an extent which may appear extreme. The fact that we have been able to show a close correspondence between the anticipations thus derived and the experimental results must be regarded as an independent demonstration of the fidelity with which constitutional formulæ depict molecular configuration.

6. *Report on the Study of Isomorphous Sulphonic Derivatives of Benzene.*

See Reports, p. 82.

MONDAY, SEPTEMBER 4.

Joint Discussion with Sub-Section K on the Part played by Enzymes in the Economy of Plants and Animals.

(i) *Opened by* Dr. E. F. ARMSTRONG.

(ii) *The Velocity of Formation of Enzyme Systems.*

By Professor H. EULER.

In studying the alteration of enzyme activity during the culture of micro-organisms in different mediums varying results have been obtained by previous investigators depending on the species of yeast selected, the condition of the yeast before the cultivation, and the nature and duration of the 'training.' No experiments having been published on the velocity of the increase of enzyme action, preliminary researches in this direction have been undertaken in continuation of experiments made two years ago with Miss af Ugglas on the increase of the amount of invertase in yeast after cultivation in sucrose solutions. The amount of this increase appears to be characteristic for each species of yeast and the form of the curve connecting the increase of inverting power with the period of cultivation is in all cases the same. Experiments on the fermentation of glucose and galatose gave similar results.

It seems that the power of micro-organisms to adapt themselves to the cultural conditions can be expressed by constants which are characteristic for every species.

The following Paper was then read:—

Some Points concerning the Treatment of Wheaten Flour.

By A. E. HUMPHRIES.

At the Leicester and Winnipeg meetings of this Association the author dealt with some phases of the complex questions concerning the quality of wheaten flour. Great importance must be attached to 'strength,' a flour's capacity for making big, shapely, and therefore well-aerated loaves. The nice appearance of food is a factor affecting its dietetic value. The whiteness of bread depends to a very great extent upon the 'strength' of the flour used, for the good appearance of bread depends very largely on the perfect aeration of the loaf. 'Strength' does not depend upon any one factor. A flour with a high protein-content is not necessarily strong. A flour with a low protein content is probably, but not necessarily, weak.

The size of the loaf depends upon the production of sufficient gas during fermentation, more particularly during the later stages, and upon the gas-retaining capacity of the dough. The yeast must have a sufficiency of sugar, nitrogenous and mineral foods in forms which it can assimilate. Flour itself does not contain sufficient sugar for the requirements of the yeast. As a general proposition it is true to say that flour made from wheats harvested in moist atmospheric conditions yield as a result of diastatic action during panary fermentation a sufficient quantity of sugar, those harvested in hot dry conditions do not. The yeast requires its nitrogenous food in a very simple form. Flours containing a very high percentage of nitrogenous matter do not necessarily provide a sufficiency of nitrogenous yeast-food. It is believed that yeast can obtain all the mineral matter it requires from flour, but there are cases in which the addition of mineral phosphates does increase the yield of gas in panary fermentation conducted under commercial conditions. A flour may possess a high percentage of gluten, but unless it yields in fermentation sufficient gas to overcome the great and variable leak, and thoroughly to inflate the dough in the latest stages of the breadmaking process, it would be accounted weak.

Furthermore, a flour may yield more than sufficient gas at all stages of fermentation and may even possess a high percentage of nitrogenous matter and

yet produce very small loaves. Dr. Hardy at the Winnipeg meeting of this Association showed that gluten loses it's tenacity and ductility if it be deprived of its electrolytes. Prof. T. B. Wood has demonstrated the profound influence which very dilute solutions of acids, alkalis, and salts have on the physical characteristics of gluten. It has been found that additions of very small percentages of salts natural to flour or wheaten ash do increase the size of the loaf even though the production of gas in fermentation be unaffected or actually diminished.

The author came across a case in which the mere addition of water, if made at a time substantially prior to dough making, increased the strength of the flour to an extraordinary extent, even though the yield of gas in fermentation was not appreciably increased thereby.

He therefore, with the assistance of his colleague, Mr. A. G. Simpson, made an investigation of the changes produced, the results of which were set forth in detail. The most striking change in the flour itself appears to be the transformation of organic phosphorus compounds into inorganic. As part of these investigations, it has been found that during the process of baking a large proportion of the organic phosphorus compounds becomes inorganic.

British millers nowadays obtain their raw material from all parts of the world, a multitude of varieties raised in environments ranging from arctic or semi-arctic to tropical or semi-tropical. The climatic conditions in most districts also vary greatly from season to season. From such extremely diverse and variable materials, they have to produce flours of uniform qualities. It is therefore right and proper that they should be allowed to make use of the advances in chemical knowledge in the treatment of wheats and flours. Sometimes the desirable treatment can be limited to the adjustment of water content, Nature herself being thereby enabled to effect the necessary changes.

Sometimes the addition of water fails to bring about these changes, or for various reasons it is undesirable to raise the water content sufficiently, and in such cases the addition of diastatic bodies, nitrogenous yeast-foods and salts natural to wheat or wheaten ash is desirable and should be permitted. But inasmuch as such permission might be abused, a Board of Reference consisting of highly qualified physiologists, chemists, and business men should be established, to whom all such processes and additions should be submitted, and to whom millers and bakers should be responsible in such matters.

TUESDAY, SEPTEMBER 5.

The following Papers and Reports were read :—

1. *Discussion on Colloids.*

(i) *The Theory of Colloids. By* Professor H. FREUNDLICH.

The classical researches of Graham pointed to a fundamental difference between crystalline and colloidal substances. The work of Zsigmondy with the ultramicroscope proved colloidal solutions to be two-phase systems, containing suspended particles. The quantitative experiments of Perrin and of Svedberg, dealing with the Brownian movement, proved the colloidal solutions to form a connecting link, without any sharp discontinuity, between coarse suspensions on the one hand and true solutions on the other, although the differences between the extreme terms of the series are very marked. Recent work on true solutions, especially in respect to colour and solubility, indicates that the simple theory of van't Hoff fails to take account of certain important factors, notably of the combination of the dissolved substance with the solvent which undoubtedly occurs in true solutions. On the other hand, coarse suspensions are only formed by very sparingly soluble substances, which have little tendency to react with the solvent. Colloidal solutions stand between these two extremes. One class, distinguished from coarse suspensions only by

the ultramicroscopic dimensions of their particles, are termed 'Suspension-colloids' or 'Lyophobic Sols.' These include colloidal metals, sulphides, and many hydroxides. 'Emulsion colloids,' or 'Lyophilic sols,' which include albumin, gelatin, starch, &c., approach more nearly to the true solutions. The members of this latter class are far more irregular in their behaviour than those of the former.

The question whether the particles of colloidal solutions are necessarily amorphous, is not easily answered, and it is not yet known how far a crystalline solid may be sub-divided and yet retain its crystalline properties. The particles of many colloidal solutions approach molecular dimensions, and it cannot be assumed without proof that they retain the properties of the corresponding phases in larger mass. In many cases the particles are certainly amorphous.

Adsorption is chiefly manifested by amorphous substances, and the substances adsorbed are frequently of high molecular weight. It remains uncertain whether adsorption is an effect of surface condensation, solid solution, or chemical combination, although the author inclines towards the first of these views. Owing to the great adsorbing power of amorphous substances, it is almost impossible to obtain a pure colloidal solution. The tendency of small particles to become larger, and to be transformed into crystals, is greatly lessened by the presence of absorbed impurities. Thus the amorphous condition of the particles favours adsorption, and this again favours the maintenance of the colloidal state. Other factors affecting the stability are the internal friction of the liquid and the electrical charge on the particles.

The electrical charge is of importance in the coagulation of suspension colloids, the addition of an electrolyte, by discharging the particles, facilitating coagulation. When the sol is positively charged, as in colloidal metallic hydroxides, the order of influence of coagulating agents is the reverse of that which is found with negatively charged sols, such as colloidal metals and sulphides. A series of experiments by Elisafoff and the author on the influence of electrolytes in diminishing the electroendosmosis of a solvent shows that a complete parallelism exists between this effect and the discharging effect of the same electrolytes on a hydrosol.

In the case of emulsion-colloids, electrical conditions are of far less importance, and the determining factors are chiefly the individual characters of the substances concerned.

In conclusion, attention was drawn to the importance of colloid chemistry or, in a wider sense, of capillary chemistry, in its bearings on physiological problems.

(ii) *Colloids in Pharmacology.* *By* Dr. GEORGE BARGER.

(iii) *The Adsorption of Iodine by the Glucoside Saponarin.*

By Dr. GEORGE BARGER.

Saponarin is a glucoside occurring in *Saponaria officinalis* and other plants; it has the composition $C_{21}H_{24}O_{12}$ (MWt=468), and is obtained pure by crystallisation from pyridine. It has been fully characterised chemically,[1] and has been shown to yield on hydrolysis glucose and the colouring matter vitexin.[2] Saponarin was first known to botanists as 'soluble starch,' on account of the blue coloration given by its solutions on addition of iodine dissolved in potassium iodide. When the pure crystalline substance is shaken with water at room temperature, a solution is formed containing about one part in 7,000, which is *not* coloured blue by iodine. The solubility in boiling water is about 1 : 1000; on cooling, the glucoside does not crystallise out for some days, but remains dissolved as a colloidal solution, and this solution closely resembles a solution of soluble starch as regards its behaviour towards iodine. A more concentrated hydrosol can be produced by acidifying a solution of the glucoside in alkali, in which it is readily soluble; but this, of course, introduces a salt. In the cell-sap of *Saponaria* the substance is held in solution by saponin. In order to

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[1] *Journ. Chem. Soc.*, 1906, 89, 1210.

[2] First isolated by A. G. Perkin, *Journ. Chem. Soc.*, 1898, 73, 1030.

obtain a pure hydrosol, free from other substances, it is best to boil the glucoside with water in a quartz vessel.

The aqueous solutions of saponarin, obtained by any of the above methods, are seen to be colloidal when examined ultra-microscopically. The alkaline solutions appear to contain particles of various sizes; neutralisation is marked by the appearance of a large number of small particles. The author is indebted to Dr. W. M. Bayliss, F.R.S., for these observations.

As in the case of starch, the addition of a pure aqueous iodine solution to the hydrosol does not bring about a blue coloration which, however, appears on the addition of potassium iodide. It is found that in the present case many other salts (ammonium chloride, aluminium sulphate) are also effective. The blue colour disappears on the addition of organic solvents or of sodium thiosulphate; also (temporarily) on heating.

If, together with the iodine, but little salt is added, the blue adsorption compound remains dissolved, but the further addition of electrolytes causes flocculation and the separation of a dark blue gel. The concentration of salt required depends primarily on the cation, and is in accordance with Schulze's law. Thus in a given case for a number of K, Na, NH_4 salts this concentration was 0·053 gram equivalents per litre, for Ba, Ca, Sr about 0·0047, and for Al salts 0·0006. If electrolytes are excluded as far as possible, the blue hydrosol does not travel appreciably with a current of 110 volts.

The conductivity of the blue hydrosol is less than that of the potassium iodide contained in it, so that some of the salt is probably adsorbed, and this salt, or its cation, favours the adsorption of iodine by saponarin, just as cations facilitate the absorption of congo red by filter paper.[3] Owing to experimental difficulties it has not yet been possible to determine the effect of the valency of the cation.

The iodine content of the blue hydrogel depends on the concentration of the iodine left in aqueous solution, as was shown for starch by Kuster,[4] and for basic lanthanum acetate by W. Biltz.[5]

Preliminary experiments yielded the following results.

C_w	C_s (found)	C_s (calc.)
0·0000533	0·080	0·073
0·000171	0·109	0·110
0·000376	0·124	0·126
0·000606	0·131	0·132
0·000792	0·133	0·133

Here C represents the free iodine (in grams) remaining in 1 c.c of water and C_w the iodine precipitated with 1 gram of Saponarin. The third column is calculated according to the formula $C_s = a[C_w]^n$, where $a = 0·47$ and $n = 0·166$. The value for n is much smaller than is generally the case with solid adsorbents (*e g.*, charcoal). It is apparently somewhat higher in very dilute solution. The formula does not apply to concentrated solutions of iodine, for which n falls off much below 0·166.

(iv) *The Colloid Theory of Cements.* *By* Dr. C. H. DESCH.

The explanation of the setting of calcareous cements, as caused by the crystallisation of the products of hydrolysis from a supersaturated solution, fails to account for the great mechanical strength of such cements. The colloid hypothesis proposed by Michaelis attributes the setting to the formation of a gel of calcium silicate, which subsequently hardens by loss of water and adsorption of lime. Microscopical examination confirms Michaelis' view. The only constituent of the cement which is acted on is the alite. The hydrolysis of the complex substances contained in the alite first sets free calcium aluminate, which separates in the form of crystals. This constitutes the initial set. The calcium silicate is more slowly hydrolysed, and the calcium monosilicate produced, being extremely insoluble, separates as a colloidal gel. A part

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[3] Bayliss, *Biochem. Journ.*, 1906, **1**, 175.

[4] *Annalen*, 1894, **283**, 360.

[5] *Ber.*, 1904, **37**, 719.

of the calcium hydroxide liberated crystallises in large plates, and is readily detected by the microscope, whilst another part is adsorbed by the silicate gel. The gradual increase of strength which is characteristic of calcareous cements is a consequence of the continued adsorption and of the physical charges in the structure of the gel. •

The colloids formed may be examined and characterised by staining with dyes, such as methylene blue, patent blue, and safranin. The principal difficulty in the microscopical examination of cement has hitherto been the brittleness of the material, making it impossible to grind very thin sections, resulting in loss of clearness. This may be avoided by treating the cement as a metallographic specimen, grinding and polishing one surface only, and examining under vertical illumination after etching with weak acids or staining with other reagents.

(v) *The Rate of Coagulation of Colloidal Copper.*

By H. H. Paine, *M.A.*, *B.Sc.*

The copper colloidal solution studied was prepared by Bredig's electrical method, a positive hydrosol being thus obtained. The coagulation of this solution by means of simple salts, such as sodium sulphate or potassium nitrate, appears to be a gradual process. The precipitated gel can be separated from the solution by allowing it to settle; the clear liquid containing the copper not yet coagulated can then be drawn off. The amount of copper present can be determined volumetrically by titrating in the warm with dilute nitric acid, the disappearance of the colour of the liquid indicating the complete solution of the copper by the equivalent quantity of acid. This estimation of the copper still in colloidal solution can be made after definite intervals of time from the addition of the salt. The course of the coagulative process can thus be studied.

The following results among others were obtained: (1) There is an initial period during which the solution remains clear and no coagulation takes place. (2) Using colloidal solutions of various concentrations, the rate of precipitation is proportional to the square of the initial concentration for the irreversible coagulation produced by salts containing a divalent anion (sodium sulphate). For salts containing monovalent anions (potassium nitrate or sodium chloride) the coagulation is not irreversible, and a more complicated relation holds. (3) For varying amounts of the electrolyte, the rate of coagulation is proportional to some power of the concentration of the salt; *i.e.*, if we increase the concentration of the salt proportionally, the rate of the coagulation will be increased proportionally also.

2. *Report on the Study of Hydro-aromatic Substances.*

See Reports, p. 99.

3. *Report on the Transformation of Aromatic Nitroamines.*

See Reports, p. 94.

4. *Report on Electroanalysis.*—See Reports, p. 98.

SECTION C.—GEOLOGY.

PRESIDENT OF THE SECTION.—ALFRED HARKER, M.A., F.R.S.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

Some Aspects of Modern Petrology.

IN accordance with the custom which permits the occupant of this chair to open the proceedings with observations on some selected subject, I wish to invite your attention to certain points concerning the genetic relations of igneous rocks. The considerations which I shall have to lay before you will be in some measure tentative and incomplete; and indeed, apart from personal shortcomings, this character must necessarily attach to any discussion of the subject which I have chosen. For petrology is at the present time in a state of transition—the transition, namely, from a merely descriptive to an inductive science—and at such a time wide differences of opinion are inevitable. If I should seem to do less than justice to some views which I do not share, I hope this fault will be attributed to the limitations of time and space, not to any intention of abusing the brief authority with which I find myself invested.

The application of microscopical and special optical methods, initiated some fifty years ago by Dr. Sorby, gave a powerful impetus to the study of the mineral constitution and minute structure of rocks, and has largely determined the course of petrological research since that epoch. For Sorby himself observation was a means to an end. His interest was in the conclusions which he was thus enabled to reach relative to the conditions under which the rocks were formed, and his contributions to this problem will always rank among the classics of geology. The great majority of his followers, however, have been content to record and compare the results of observation without pushing their inquiries further; and indeed the name 'petrography,' often applied to this line of research, correctly denotes its purely descriptive nature. A very large body of facts has now been brought together, and may be found, collated and systematised by a master-hand, in the monumental work of Rosenbusch. Beyond their intrinsic interest, the results thus placed on record must be of the highest value as furnishing one of the bases upon which may eventually be erected a coherent science of igneous rocks and igneous activity.

In earnest of this promise, recent years have witnessed a very marked revival of interest in what we must call at present the more speculative aspects of petrology. This manifests itself on the side of the petrographer in a growing disposition to seek a rational interpretation of his observations in the light of known physical principles, and on the side of the field geologist in a more constant regard for the distribution, mutual associations, and mode of occurrence of igneous rocks. I will add, as another hopeful sign of the times, a decided *rapprochement* between the laboratory and the field, too often treated in practice as distinct departments.

As regards the former, the movement which I have noticed is merely a return to the standpoint of Sorby, the father of modern petrology. It is true indeed that, before his time, the problem of the origin of igneous rocks had engaged the ingenuity of Scrope and Darwin, of Bunsen and Durocher, and many others; and the bold speculations of the heroic days of geology have justly exercised a lasting influence. The petrologist of to-day, however, has at his command a much ampler range of information than was possessed by his predecessors. In addition to the rich store of petrographical data already mentioned, he can press into service on the one hand the results of physical chemistry and on the other much additional knowledge which has been gathered concerning the structure of the earth's crust and the distribution of various rock-types, both in space and in time. Either of these branches of the subject would furnish material for a much longer address than my assurance could venture or your complacence would endure. I have chosen the geographical aspect of petrology; but, before proceeding to this, I will say a few words concerning the experimental side

Data from the Experimental Side.

That the modern developments of physical chemistry, starting from the phase rule of Willard Gibbs, must in theory furnish all that is necessary to elucidate the crystallisation of igneous rock-magmas, has long been perceived by some petrologists. This recognition is in itself an advance. Natural rock-magmas, however, are far more complex solutions than those which chemists have employed in working out their laws, and the problem in its entirety is of a kind almost to daunt inquiry. Despite the courageous attempt made by Professor Vogt, whose enthusiastic lead has done so much to inspire interest in the subject, it seems clear that the application of the laws of chemistry to the particular class of cases with which the petrologist is concerned demands as a prerequisite a large amount of experimental work in the laboratory. The high melting-points of the rock-forming minerals, their extreme viscosity, and other specific properties render such work extremely difficult and laborious. That most of the practical difficulties have now been overcome is due in the first place to Dr. A. L. Day and his colleagues of the Geophysical Laboratory at Washington, who have thus opened out what is virtually a new field of investigation. The methods of high temperature measurement have been perfected and the thermometric scale standarised up to 1550° C., thus embracing the whole range of rock formation. Calorimetric measurements have been so far improved that it is now possible, for instance, to determine specific heats, even in the highest part of this range, with an accuracy ten times greater than has hitherto been usual at ordinary temperatures. Incidentally there has been, in the hands of Mr. F. E. Wright, a notable enlargement of the scope of ordinary petrographical methods, since it has been found necessary to devise special means of measuring with precision the crystallographic and optical constants of very minute crystals.

The American chemists have already determined the temperature-range of stability of numerous rock-forming minerals. Beginning with the simpler cases and working always with chemically pure material, they have established quantitatively the mutual relations of the various possible forms in a number of two-component systems and in one of three components. So far as these instances go, the mutual lowering of melting-points in a silicate-magma is now a matter of precise measurement, and it is no longer inferred, but demonstrated, that the order of crystallisation of the minerals depends upon their relative proportions in the magma. The perfect isomorphism of the plagioclase felspars has been finally established, and a certain degree of solid solution between quite different minerals has furnished the explanation of some apparent anomalies, such, for instance, as the variable composition of the mineral pyrrhotite. As a single illustration of how these investigations in the laboratory provide the working petrologist with new instruments of research, I will cite the conception of a geological temperature-scale, the fixed points on which are given by the temperature-limits of stability of various minerals. It is often possible, for example, to ascertain whether quartz in a given rock has crystallised above or below 575° C., this being the inversion-point between the α- and β- forms of the mineral. At about 800° there is another inversion-point, above which quartz is no longer stable, but gives place to cristobalite. In like manner we know that

wollastonite in a rock must have crystallised below 1190°, pryites below 450°, and so for other cases. We may confidently hope that, with the aid of such data, we shall soon be enabled by simple inspection, to lay down in degrees the temperature-range of crystallisation of a given igneous rock.

There are now several laboratories where high-temperature research, of the rigorous order indicated, is being carried out; but the work is peculiarly arduous, and results come slowly. Some branches of the inquiry, notably those involving high pressures, and again the investigation of systems into which volatile components enter, are as yet virtually untouched. For these reasons it would be premature to hazard at this stage any more detailed forecast of the services to be rendered to petrology by synthetic experiment. I will accordingly leave this attractive subject, and pass on from the laboratory to the field.

Geographical Distribution of Igneous Rocks.

Here the existing situation is very different. Instead of following out definite lines already laid down, we are concerned in reducing to order a great mass of discrete facts drawn from many sources. The facts which enter into consideration are those touching the distribution of various igneous rocks in time, in space, and in environment, including their relation to tectonic features; the mutual association of different rock-types and any indications of law in the order of their intrusion or extrusion; and, in short, all observable relations which may be presumed to have a genetic significance. The digestion of this mass of data has already led to certain generalisations, some of which are accepted by almost all petrologists, while others must be regarded as still on their trial.

Of the former kind is the conception of petrographical provinces, which was put forward by Professor Judd twenty-five years ago, and has exercised a profound influence on the trend of petrological speculation. It is now well established that we can recognise more or less clearly defined tracts, within which the igneous rocks, belonging to a given period of igneous activity, present a certain community of petrographical characters, traceable through all their diversity or at least obscured only in some of the more extreme members of the assemblage. Further, that a province possessing an individuality of this kind may differ widely in this respect from a neighbouring province of like date; while, on the other hand, a striking similarity may exist between provinces widely separated in situation or in age. It is natural to attribute community of chemical and mineralogical characters among associated rocks to community of origin. The simplest hypothesis is that which supposes all the igneous rocks of a given province to be derived by processes of differentiation from a single parent-magma. This may be conceived, for the sake of simplicity, as initially homogeneous, though doubtless some of the causes which contribute to promote heterogeneity were operative from the earliest stage. Granted this hypothesis, it follows that the points of resemblance among the rocks of a province will indicate the nature of the common parent-magma, while the points of diversity will throw light on the causes of differentiation. The observed sequence in time of the various associated rock-types will also have an evident significance, especially if, as there are good reasons for believing, differentiation in igneous rock-magmas is largely bound up with progressive crystallisation. Those petrologists, on the other hand, who attach importance to the absorption or 'assimilation' of solid rock-matter by molten magmas, are bound to consider both the nature of the chemical variation and the local distribution of the different types with constant reference to the composition of the country-rocks. The balance of opinion, and I think of argument, would assign the variation, at least in the main, to differentiation; and there are well-known principles, chemical and mechanical, which theoretically must operate to produce a diversity of ultimate products from a magma originally uniform. How far these principles are in practice adequate to the demands which have been made on them, is a question, not to be finally resolved without quantitative knowledge which is still a desideratum. Experiment may in time come to our aid. My design to-day is rather to offer some remarks upon a distinct, though allied, problem—viz., that presented by the petrographical provinces themselves.

The geographical distribution of different kinds of igneous rocks long ago engaged the attention of Humboldt, Boué, and other geologists, and the subject

has always possessed a certain interest in view of the association of most metalliferous deposits with igneous rocks. It has, however, acquired a new importance in recent years in connection with questions of petrogenesis which are still under discussion. The problem is, in brief, to account for the existence of petrographical provinces and for the observed facts relative to their distribution. One theory, advocated especially by Dr. G. F. Becker, invokes primæval differences in composition between different parts of the globe, which have persisted throughout geological time. It involves the hypothesis that igneous rock-magmas result from the refusion of pre-existing rocks within a limited area. Indeed Becker discards altogether the doctrine of differentiation, and conceives the varied assemblage of rocks in a given province as produced by admixture from a certain number of primitive types. These, he says, should be recognisable by their wide distribution and constant character. It is clear, however, that, on the hypothesis of admixture, the primitive types must be those of extreme composition. These are, in fact, always the rarest and the most variable, pointing not to admixture but to differentiation as the cause of the diversity. A theory which attributes the special characteristics of petrographical provinces to permanent heterogeneity in the composition of the globe is difficult to reconcile with the small extent and sharp definition of some strongly characterised provinces, such as that of Assynt or of the Bohemian Mittelgebirge. A more fatal objection is that petrographical provinces are *not* in fact permanent. A good illustration is afforded by the midland valley of Scotland, an area our knowledge of which has been much enlarged by the recent work of the Geological Survey. It was the theatre of igneous activity in Lower Old Red Sandstone times and again in the Carboniferous, but, in respect of mineralogical and chemical composition, the two suites of rocks present a striking contrast. The Old Red Sandstone lavas are mostly andesites, though ranging from basalts on the one hand to rhyolites on the other, and the associated intrusions are mainly of diorite, quartz-diorite, and granite, with porphyrites and other dyke-rocks. In the Carboniferous, on the other hand, we find porphyritic basalts, mugearites, and trachytes (including phonolitic types), with picrites, teschenites, monchiquites, orthophyres, and other allied rocks. It would be possible to cite many other cases illustrating the same point.

The Alkaline and Calcic Branches.

The two Scottish suites of Upper Palæozoic rocks just mentioned fall into opposite categories with reference to what is now becoming recognised as the most fundamental distinction to be made among igneous rocks. The earlier set is typical of the andesitic division and the later of the tephritic; or, using other equivalent names, the one belongs to the calcic (or 'alkali-calcic') branch and the other to the alkaline. I will adopt the latter terminology as being generally familiar to petrologists; but the characteristics of the two branches, which are too well known to need recapitulation here, are more clearly definable in mineralogical than in chemical language. This two-fold division of igneous rocks is, of course, in no wise a final or exhaustive treatment of the subject; but as a first step towards a natural or genetic classification it seems to be established beyond question. No third branch in any degree comparable with the two and distinct from them has been proposed. The charnockites and their allies represent but a single rock-series, and Rosenbusch has not made clear his reasons for separating them from the calcic rocks. The 'spilitic' suite of Dewey and Flett is made to embrace a somewhat miscellaneous collection of types, and any close genetic relationship among them can scarcely be considered as proved. It is perhaps permissible to suggest that, *e.g.*, the quartz-diabases are, here as in Scotland, quite distinct in their affinities from the types rich in soda. These latter, constituting the bulk of the proposed suite, would seem to belong quite naturally to the alkaline branch, the question of the magmatic or solfataric origin of the albite being in this connection immaterial.

A given petrographical province is either of calcic or of alkaline facies, typical members of the two branches not being found together. The apparent exceptions are, I think, not such as to modify very seriously the general rule. Mr. Thomas, in describing an interesting suite of rocks from Western Pembrokeshire, recognises the alkaline affinities of most of them, but assigns some of the more basic types to the opposite branch. In a very varied assemblage we not

infrequently meet with a few extreme types which, occurring in a calcic province, recall the characters of alkaline rocks, or conversely. Such anomalies have been pointed out by Daly, Whitman Cross, and others. They are found among the later derived types, referable to prolonged or repeated differentiation, and they are to be expected especially where the initial magma was not very strongly characterised as either calcic or alkaline.

Having regard to the known exposures of igneous rocks over the existing land-surface of the globe, it seems that there is a very decided preponderance of the calcic over the alkaline branch. This, as we shall see, is probably a fact of real significance, but it is nevertheless noticeable that increasing knowledge tends partly to redress the balance. In our own country, in addition to the Scottish Carboniferous rocks and those probably of Ordovician age in Pembrokeshire, we have the remarkable Lower Palæozoic intrusions of Assynt, in Sutherland, of strongly alkaline character, as described by Dr. Teall and more recently by Dr Shand; while Dr. Flett has recognised alkaline rocks of more than one age in Cornwall and Devon, and Mr. Tyrrell is engaged in studying another interesting province, of Permian age, in Ayrshire.

That the distinction between the alkaline and the calcic rocks embodies some principle of real and fundamental significance becomes very apparent when we look at the geographical distribution of the two branches. Taking what the German petrographers call the 'younger' igneous rocks, *i.e.*, those belonging to the latest system of igneous activity, we find it possible to map out the active parts of the earth's crust into great continuous regions of alkaline rocks on the one hand and of calcic on the other. An alkaline region comprises numerous petrographical provinces, which may differ notably from one another, but agree in being all of alkaline facies. In like manner a common calcic facies unites other provinces, which collectively make up a continuous calcic region. Concerning the igneous rocks of earlier periods our knowledge is less complete, but, so far as it goes, it points to the same general conclusions.

These considerations enable us to simplify at the outset the problem before us. If we would seek the meaning and origin of petrographical provinces, we must inquire in the first place how igneous rocks as a whole come to group themselves under two great categories, which, at any one period of igneous activity, are found in separate regions of the earth's crust. The fact that a given district may form part of a calcic province at one period and of an alkaline one at another, precludes the hypothesis that the composition of igneous rocks depends in any degree upon peculiarities inherent from the beginning in the subjacent crust. The same objection applies with scarcely less force to various conflicting suggestions based on an assumed absorption or 'assimilation' of sedimentary rocks by igneous magmas. Thus Jensen supposes the alkaline rocks to be derived by the assimilation or fusion of alkaline sediments at great depths. Daly propounds the more elaborate, and on a first view paradoxical, theory that alkaline have been derived from calcic magmas as a consequence of the absorption of limestones. These geologists agree in regarding the alkaline rocks as relatively unimportant in their actual development and in some sense abnormal in their origin. For Suess, on the other hand, it is the calcic rocks which owe their distinctive characters to an absorption of sedimentary material, enriching the magma in lime and magnesia. Apart from difficulties of the physical and chemical kind, all such theories fail to satisfy, in that they ignore the separation of the two branches of igneous rocks in different regions of the globe, each of which includes sediments of every kind. What then is the real significance of this regional separation? The obvious way of approaching the question is to inquire first whether the alkaline and calcic regions of the globe present any notable differences of a kind other than petrographical.

Relation between Tectonic and Petrographical Facies.

The close connection between igneous activity and displacements of the earth's crust has been traced by Suess, Lossen, Bertrand, de Lapparent, and others, and is a fact sufficiently well recognised. We have here indeed two different ways of relieving unequal stresses in the crust, and it is not surprising that they show a broad general coincidence both in space and in time. We can, however, go farther. Not only the distribution of igneous rocks in general, but the distribution of different kinds of rocks is seen to stand in unmistakable relation to the

leading tectonic features of the globe. It is very noticeable that petrographical provinces, and in particular provinces belonging to opposite branches, are often divided by important orographic lines. This is illustrated by the Cordilleran chain in both North and South America, and again by some of the principal arcs of the Alpine system in Europe. If now we examine the actual distribution more closely, in the light of Suess's analysis of the continents and oceanic basins, we perceive another relation still more significant. It is that, as regards the younger igneous rocks, the main alkaline and calcic regions correspond to the areas characterised by the Atlantic and Pacific types of coast line respectively. I briefly drew attention to this correspondence in 1896, and a few years later Professor Becke, of Vienna, arrived independently at the same generalisation. Recalling the two classes of crust-movements discriminated by Suess, he says it appears that the alkaline rocks are typically associated with subsidence due to radial contraction of the globe, and the calcic rocks with folding due to lateral compression. The greater part of Becke's memoir is devoted to a comparison of the two branches in respect of chemical composition: but here, I think, he has been misled by taking as representative of the whole alkaline '*Sippe*' or tribe the rocks of one small and peculiar province, that of the Bohemian Mittelgebirge. Some petrologists have followed Becke in adopting the terms Atlantic and Pacific as names, or at least synonyms, for the two branches of igneous rocks. Others, perhaps with some justice, deprecate the use of the same terms in a petrographical as well as a tectonic sense, so long as the implied relationship is still a matter of discussion.

I would point out in passing that the association of the alkaline rocks with areas of subsidence helps to explain the relatively small part which they play in the visible portion of the earth's surface. We may not unreasonably conjecture, for instance, that the volcanic islands scattered sparingly over the face of the Atlantic Ocean, from the Azores to Tristan d'Acunha, are merely fragments of a very extensive tract of alkaline rocks now submerged.

The generalisation associated with the name of Becke, in so far as it may ultimately commend itself to general acceptance, must have an important bearing on the problem of the origin of petrographical differences The time is not ripe for any dogmatic pronouncement, but I will venture to indicate briefly the general trend of the inferences to be drawn. It seems clear that only a trivial effect at most can be allowed to original and permanent heterogeneity of the earth's crust, or to such accidents as the absorption by an igneous magma of a limited amount of the country-rock. The division between alkaline and calcic regions, and the separation of distinct provinces within such regions, point rather to the same general cause which, at a later stage, produced the diversity of rock-types within a single province, that is to magmatic differentiation. Here, however, the differentiation postulated must be on a very wide scale, and must take effect in the horizontal direction. Its close connection with crust-movements clearly indicates differential stress as an essential element in the process. The actual mechanism can be at present only a matter of speculation, but I think the clue will be found in such observations as those of Mr. Barrow on the pegmatites of the Scottish Highlands. Conceive an extensive tract to be underlain by a zone which is neither solid nor liquid, but composed of crystals with an interstitial fluid magma. If this be subjected to different pressures in different parts of its horizontal extent, its uniformity will necessarily be disturbed, the fluid portion being squeezed out at places of higher pressure and driven to places of lower pressure. The precise nature of the differentiation thus set up will depend on the relative compositions of the crystalline and fluid portions, and the subject could not be very profitably discussed without fuller knowledge concerning the order of crystallisation in rock-magmas. Whether or not the explanation be ultimately found in this direction, the relation between the two tectonic types and the two branches of igneous rocks must, I think, find a place in the final solution of the problem.

I intimated at the outset that my remarks would not be confined to matters already settled and indisputable. It will be easily understood that some statements which I have made, for the sake of clearness, without qualification are subject to exceptions, and exceptions have, indeed, been urged by critics whose opinions are entitled to respect. The most uncompromising of these critics, Dr. Whitman Cross, has laid it down that: 'Only generalisations without known

exceptions in experience can be applied to the construction of a system that may be called natural.' I hold, on the contrary, that such a science as Geology can be advanced only by the inductive method, which implies provisional hypotheses and successive approximations to the truth. A generalisation which brings together a mass of scattered observations, and endows them with meaning, is not invalidated by the discovery of exceptions. These merely prove that it is not a final expression of the whole truth, and may point the way to its revision and correction.

Take, for instance, our provisional law of the distribution of the two branches of igneous rocks in defined regions. It has been objected that leucitic lavas, having therefore very decided alkaline or Atlantic affinities, are known at several places within the limits of the main Pacific region, where they are associated with andesitic and other calcic rocks. Now, the only area for which we have anything like full information is the island of Java. Here, according to Verbeek and Fennema, the great plateau-lavas of Tertiary age are exclusively of andesitic types, and the same is true of the long chain of 116 volcanic centres, which represent the later revival of activity. As against this record there are five volcanoes, long extinct, which at one stage erupted leucitic lavas. Whether we suppose these to be aberrant derivatives from an andesitic magma, or, much more probably, an incursion from the neighbouring alkaline region, it seems reasonable to regard these very exceptional occurrences as of the second order of importance, and to set them aside in a first attempt to reduce the facts to order.

The discovery of various alkaline rocks on Hawaii, Samoa, Raratonga, Tahiti, and other islands in the midst of the Pacific Ocean raises, I think, a different question. So far as is known, these rocks are not found in close association with characteristic calcic types. Suess' masterly discussion of all the geographical and hydrographical data hitherto obtained makes it clear that an Atlantic as well as a Pacific element of structure enters into some parts of the Pacific basin. In certain areas, such as the Galapagos Archipelago, the coming in of the Atlantic *régime* is quite clearly reflected in an alkaline facies of the igneous rocks, and such exceptions are therefore of the kind which go to prove the rule. Both Max Weber and Lacroix have expressed the opinion that the andesitic branch of rocks is characteristic of the border of the great Pacific basin rather than the interior It is possible that further knowledge may justify this conclusion, and still only confirm the relation which is claimed between the two tectonic types and the two petrographical facies. Meanwhile we find clear evidence elsewhere that vertical subsidence and lateral thrust have sometimes occurred in the same region or in the same petrographical province; nor need we go far from home to learn that the complexity of structure thus implied is accompanied by a corresponding peculiarity of petrographical facies.

The North British Tertiary Province.

In order to illustrate this point in a concrete instance, I will discuss very briefly a single petrographical province, viz., that which occupied the northern part of Britain in early Tertiary times. Professor Judd has regarded this as forming part of a larger 'Brito-Icelandic province'; but, while recognising many affinities between our rocks and those of higher latitudes, I think that the North British area possesses enough individuality to be more properly treated as a distinct unit. The record of igneous action here is exceptionally complete and well displayed. Our knowledge of it is derived in the first place from Professor Zirkel, Sir Archibald Geikie, and Professor Judd, and more recently from the detailed work carried out by the Geological Survey of Scotland. This latter is, as regards the Isle of Mull, still in progress, and will doubtless when completed throw additional light on some questions still obscure.

The province includes all western and southern Scotland, with the northern part of Ireland, and extends southward as far as Anglesey and Yorkshire, but the chief theatre of igneous activity was the sunken and faulted tract of the Inner Hebrides, between the mainland of Scotland on the one hand and the Archæan *massif* of the Outer Isles on the other. It is here that the volcanic accumulations attain their greatest thickness, and here, closely set along a N.-S. line, are the plutonic centres of Skye, Rum, Ardnamurchan, and Mull. Further

south are the volcanic plateau of Antrim and the neighbouring plutonic centres of the Mourne Mountains and Carlingford, while the two centres of Arran and that of Ailsa lie on a parallel line only a little further east. In addition it is clear that igneous activity extended westward over a tract now submerged under the Atlantic, and here too plutonic centres were not wanting. One is exposed in St. Kilda, 50 miles west of the Outer Hebrides, and another has been inferred by Professor Cole from a study of the stones dredged on the Porcupine Bank, 150 miles west of Ireland.

The connection of igneous action in this province with the subsidence of faulted blocks of country is too plain to be missed; and so far, excepting the tendency to a definite alignment of the foci of activity, we seem to be dealing with a typical example of the Atlantic *régime*. The actual tectonic relations are, however, of a more complex kind, and undoubtedly involve the element of lateral thrust as well as vertical subsidence. This is more particularly so in the neighbourhood of those special centres which were marked at one stage by plutonic intrusions. The evidence is seen in sharp anticlinal folding; sometimes also in crush-brecciation along quasi-horizontal bands and (in Rum) contemporaneous gneissic structure in the plutonic masses themselves. The disturbances in Mull, as described by Mr. Bailey, are especially interesting. The whole eastern coast-line of the island is determined by a system of concentric curved axes of folding, affecting all the rocks up to the Tertiary basalts, which are in places tilted almost vertically. The curved axes are disposed with reference to the plutonic centre of the island, and a somewhat similar arrangement is found on the east side of the Skye centre. All these facts go to show that in the district surrounding any one of the special centres there was developed a complex system of stresses, which found relief partly in igneous action, partly in displacements of the solid rocks. Nor were the effects confined to the plutonic phase. At a later epoch the influence of these local stresses is sometimes indicated by the diversion of the very numerous dykes from their normal northwesterly direction to a radial arrangement about the special centres, as is seen partly in Skye and more strikingly in Rum. There are also local groups of dykes developed only in those districts, and these again sometimes have a radial arrangement. More remarkable are the groups of inclined sheets which are found about the same centres, usually intersecting the plutonic rocks and a small fringing belt, and constantly dipping inwards. Such sheets occur in immense numbers in the gabbro mountains of Skye and Mull, and they are to be recognised also in Rum and Ardnamurchan.

It is plain then that this province exemplifies at once the two tectonic types distinguished by Suess. There has been a general subsidence, affecting the area as a whole but not all parts equally, and with this we must connect those groups of igneous rocks which have a wide distribution throughout the province. But there have also been movements in the lateral sense more strictly localised and more sharply accentuated, and to these belong evidently the plutonic rocks with various other groups which are their satellites. I have pointed out these facts elsewhere, but failed to follow out the logical conclusion on the petrographical side. Influenced by the strongly marked characters of the plutonic series, I assigned the North British Tertiary rocks, not without some misgivings, to the calcic or Pacific region. Suess, having regard probably to the broader tectonic features rather than to petrographical data, has included our area in the Atlantic region.

Concerning the calcic facies of the plutonic rocks there can be no question. They constitute a well-defined 'rock-series,' intruded in order of decreasing basicity, and ranging from ultrabasic to thoroughly acid. The ultrabasic rocks, as developed in Rum and Skye, have a lime-felspar as one of their chief components : there are no picrites (in the original sense of Tschermak) or other alkaline types. The eucrite group, found in Rum, Ardnamurchan, and the Carlingford district, is also characterised by a felspar near anorthite. Gabbros are represented at nearly all the several centres, and in Arran they are accompanied by norites. The granites and granophyres fall into two sub-groups. The less acid is usually augitic, while the more acid, found in Arran, St. Kilda, and the Mourne Mountains, carries hornblende and sometimes biotite.

This series is known in various provinces of Pacific facies. A peculiarity of it is that it is a broken series, types of mean acidity being absent. This has an

interesting consequence. In many places a granite magma, invading rocks so different from itself as gabbro or eucrite, has caused energetic mutual reactions, and a set of hybrid rocks has been produced, which serves in a limited sense to fill the gap in the series.

The only known exceptions to the calcic facies of our Tertiary plutonic rocks are perhaps significant in that they occur near the northern and southern limits of the principal belt of activity. The massive gently-inclined sheets of granite and granophyre which make up part of the southern end of Raasay consist largely of microperthite, and contain abundant riebeckite, a distinctively alkaline mineral known at only one spot in Skye. The microperthitic granites of Arran do not carry riebeckite, but it is found in the well-known rock of Ailsa Craig, further south

The local groups of minor intrusions—acid, basic, and ultrabasic—related to the several plutonic centres have the same calcic facies as the plutonic rocks of which they are satellites. It appears, however, that they sometimes tend to a more alkaline composition towards the borders of their respective districts. Thus, the Skye granite is surrounded by a roughly oval area, within which are found numerous dykes and sills of felsite and granophyre, in general augitic; but on the fringe of the area these rocks give place to orthophyres, with biotite or hornblende, and to bostonites.

Turn now to the rocks of regional distribution. The most important are, of course, the basalt lavas. They are all felspar-basalts, but a very general feature is the filling of their numerous amygdaloidal cavities with zeolites, such as analcime, natrolite, chabazite, and stilbite. These minerals are certainly not mere weathering-products. When I examined the basalts of Skye and the Small Isles some years ago, I regarded the zeolites as solfataric products, formed at the expense of the felspar by the action of volcanic water, while the rocks were still at a somewhat high temperature. Subsequent reconsideration has led me to consider these minerals rather as primary constituents of the rock, crystallised directly from the final residual magma, which had become relatively enriched in water by the abstraction of the anhydrous minerals. Such was the conclusion reached by Mr. James Strachan for the Antrim basalts, and a study of examples from Mull and Skye has enabled me to confirm and extend his interesting observations. Analcime in particular is not always confined to the steam-cavities, but in some cases occurs interstitially in the rock, where it is certainly not derived from felspar, and, indeed, has all the appearance of a primary constituent. The augite of these analcime-bearing basalts has in thin slices a purplish tint, with sensible pleochroism. From these and other features it appears that this group of rocks reveals on examination decided, though not very strongly marked, alkaline affinities.

Volcanic rocks of other than basaltic composition are not largely developed. They include both rhyolites and trachytes, the former without very distinctive characters, but the latter falling naturally into the alkaline division. In describing formerly a group of rhyolites and trachytes on the northern border of the Cuillins, I connected it with the neighbouring plutonic centre, but I have since found other trachytes in Skye: there is a fine development exposed in the glen above Bracadale. From this, and from the situation of the Antrim rhyolites, I infer that these felspathic and acid lavas, though distributed sporadically, belong to the regional or Atlantic suite.

Consider next the wide-spread group of basic sills. The common non-porphyritic dolerite sills have, in most districts, little that is indicative of alkaline affinities, though chemical analyses show a rather noteworthy amount of soda. In the porphyritic dolerites this characteristic is much more apparent, and indeed these rocks are almost identical with the 'Markle type' so largely represented among the alkaline rocks of the Scottish Carboniferous province. Mugearite, a type still richer in alkalis, is likewise common to the two provinces. As we approach the limits of the principal belt of activity, alkaline characteristics become well marked even in the common non-porphyritic dolerites. This is shown in Raasay and the northern part of Skye by the coming in of the purple pleochroic augite, while further north, in the Shiant Isles, analcime enters and even, according to a record of Heddle, nepheline.[1] At the other

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[1] The dolerite here is intimately associated with ultra basic rocks, as has been described by Judd.

extreme in southern Arran, occur the analcime-dolerite sills of Clauchland and Dippin.

The regional basic dykes, which are mostly posterior in age to the sills, exhibit more variety of composition. Some with abundant porphyritic felspars resemble the Markle type of dolerite, and there are others of mugearitic nature, but these are only a minority. In Argyllshire there are basic dykes with purple pleochroic augite, and even some of camptonite and monchiquite; but these latter at least I should exclude as being probably of late Palæozoic age.[1] The undoubtedly Tertiary dykes, however, exhibit a variety which can be explained only as the result of repeated differentiation. The distribution of some of the groups indicates the existence at this late stage of subsidiary centres of differentiation, distinct from the plutonic centres. Thus, trachyte dykes are found especially throughout a tract extending from the south-western part of Skye through the middle of Argyllshire, while there is an isolated area of these dykes about Drynoch, on the opposite side of the Skye mountains. Here we have an evidently alkaline type. On the other hand, there are rocks which, taken by themselves, must be assigned to the calcic division. Augite-andesites, for example, are well-known, especially in parts of western Argyllshire, in Arran and the Cumbraes, and in the outlying districts of the North of Ireland, Anglesey, and the north-east of England. That these rocks have arisen as products of a subsidiary differentiation we have in some cases almost ocular demonstration; for in Arran and elsewhere augite-andesites are found in remarkably intimate association with complementary types, often pitchstones of alkaline composition.

Even from so brief and imperfect a sketch we may, I think, draw some conclusions which have a wider application. This province exemplifies at once the two main tectonic types, and also comprises representatives of the two great branches of igneous rocks. Those rocks which are related to broad movements of Atlantic type indicate a parent magma of decided, though not strongly marked, alkaline nature; while those related to local movements of Pacific type clearly come from a calcic magma. There are some facts which suggest that the rocks tend to become more alkaline as we recede from the chief centres of activity, and this suggestion applies to some calcic as well as alkaline groups of rocks. Finally, it appears that the relative simplicity of arrangement was disturbed at a late stage by the effects of subsidiary differentiation, the province tending then to break up into districts related to new centres. Operating upon an initial magma not very strongly characterised, this later differentiation has even given rise to aberrant rock-types which overstep the petrographical boundary-line between the two branches.

Petrogenesis and Systematic Petrography.

From such considerations as I have hastily passed in review, it is evident that a survey of igneous rocks as they actually occur in the field leads to a conception of their mutual relationships very different from that embodied in the current schemes of systematic petrography. It may be of some interest, in conclusion, to expand this remark a little further, although I am sensible that in so doing I lay myself open to the charge of vain speculation.

From the petrogenetic point of view, the most fundamental division among igneous rocks is that between the alkaline and calcic branches. This result, independently arrived at on petrographical grounds by several authorities, seems to be firmly established by the broad distribution of the two branches in different regions of the globe. But, if this argument be admitted, it follows that the next step in a natural grouping of igneous rocks should be suggested by a comparison of the characteristics of the various provinces into which the great regions divide. Many of these provinces have now been partly studied, and their special characteristics can often be expressed in concise terms: *e.g.*, among alkaline rocks the relative proportion of potash to soda may be a characteristic common to a whole province. More precisely, by averaging the chemical analyses of the chief rock-types, weighted according to their relative abundance, it is possible to calculate approximately the composition of the parent-magma of

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[1] A like remark applies to the highly alkaline dykes of the Orkneys, which do not agree even in direction with the Tertiary suite.

a province. Noting that nearly identical assemblages of rocks sometimes occur in widely separate provinces and at different geological periods, we have some reason for expecting that the provincial parent-magmas may ultimately be reduced to a limited number of types. Whether these types will be sufficiently definite to serve as a basis of classification it is too early to say.

For the sake of argument, I have taken chemical composition as the criterion. It is certain, however, that a rock magma consists not of free oxides but mainly of silicate-compounds, and the variation produced by magmatic differentiation is a variation in the relative proportions of such compounds. The characteristics common to a set of cognate rock types will, therefore, be more properly expressed in mineralogical than in chemical terms. If, to fix ideas, we take as representative of a province its principal plutonic series, we shall often find that some particular mineral or some special association of minerals stands out as a distinctive feature. For instance, in the charnockite-norite series of Southern India the characteristic ferro-magnesian mineral is hypersthene; in the granite-gabbro series of the British Tertiary it is augite; and in the granite-diorite series, which predominates among the 'newer granites' of the Scottish Highlands, hornblende and biotite. These three sets of rocks, all of calcic facies, are easily distinguishable in isolated specimens.

Each such rock-series embraces types ranging from acid to ultrabasic. This variation is ascribed to a later differentiation of the parent-magma of the province, and, therefore, in an arrangement based on genetic principles, it will find expression, not in the main divisions of the scheme but in the sub-divisions. Here is an essential difference between an ideal petrogenetic classification and the petrographical systems which are, or have been, in use. If we are content to limit our study of igneous rocks to specimens in a museum, the distinction of acid, neutral, basic, and ultra-basic may seem to be one of first importance. It has, in fact, been employed for the primary divisions in some formal schemes, *e.g.*, in that put forward by Löwinson-Lessing. In a less crude system, like that of Rosenbusch, this element disappears, but the underlying idea still remains. There is a division into families, such as the granite-family and the gabbro-family, but the term, in so far as it implies blood-relationship, is a misnomer. The augite granite of Mull is evidently more closely related to its associated gabbro than it is, say, to the biotite-granite of Peterhead or the hypersthene granite of Madras.

The differentiation which evolves a varied series of plutonic rocks from a common parent-magma is clearly not of the same kind as that which gave rise to the parent-magma itself. It appears that the external mechanical element is here a less important factor, and the variation set up is, therefore, more closely in accordance with the uninterrupted course of crystallisation. This is clearly indicated when we compare the order of intrusion of the several rocks of the series with the order of crystallisation of their constituent minerals. The history of the series is in a sense epitomised in the history of each individual type, corresponding in both cases to continued fall of temperature and progressive change in the composition of the residual magma. In a large number of rocks, more particularly those of complex constitution, the order of crystallisation follows Rosenbusch's empirical law of decreasing basicity, and the plutonic intrusions then begin with the most basic type and end with the most acid. I mention this only to point out that, while the larger divisions of our ideal classification will have a certain geographical and tectonic significance, the sub-divisions will show a certain correspondence with the sequence in time of the various cognate rock-types.

To pursue the subject further would serve no useful purpose. It is clear that, if a natural—by which I mean a genetic—classification of igneous rocks is ever to become a reality, much work must first be done both in the field and in the laboratory, each petrographical province being studied from the definite standpoint of the evolution of its rock-types from one parent stock. Such researches as those of Brögger in the Christiania province may serve as a model. It would be rash to venture at present more than the most general forecast of the lines which future developments may follow; but I think it calls for no less hardihood to set limits to what may ultimately be possible in this direction. There are those who would have us abandon in despair all endeavour to place petrography upon a genetic basis, and fall back upon a rigid arbitrary

system as a final solution of the difficulty. This would be to renounce for ever the claim of this branch of geology to rank as a rational science. I have said enough to show that I am one of those who take a more hopeful view of the future of petrology, confidently expecting it to show, like the past, a record of continued progress.

The following Papers and Reports were then read :—

1. *The Geology of Portsmouth and District.*
By CLEMENT REID, *F.R.S.*

2. *Further Work on the Silurian Rocks of the Eastern Mendips.*
By Professor S. H. REYNOLDS, *M.A.*

In May 1907 a paper was published in the 'Quarterly Journal of the Geological Society' describing the igneous rocks of the Eastern Mendips, and showing that the andesite, which had previously been regarded as intrusive, was interbedded with tuff and rested on a further series of tuffs containing Silurian, probably Llandovery fossils.

In the latter part of 1907 fresh sections in fossiliferous Silurian rocks were exposed to the S.E. of the Moon's Hill quarry owing to the laying of a line of rails from the Downhead quarry, and at the Leicester meeting of the British Association in 1907 a Committee was appointed to further investigate the Silurian rocks of the Bristol area and of the Mendips. Under the auspices of this Committee a series of trenches was dug and some fossils collected which were determined by Mr. F. R. Cowper Reed and assigned by him to the Llandovery. No tuffs were met with in the area to the S.E. of the Moon's Hill quarry, the prevalent rock being a somewhat sandy mudstone. The results obtained were published in the report of the above Committee presented at Dublin in 1908.

During the present year further excavations have been carried out leading to the discovery of large additional series of fossils, which bring Mr. Reed to the conclusion that the sandy mudstones in the area to the S.E. of the Moon's Hill quarry are of Wenlock rather than Llandovery age. It has also been ascertained :—

(1) That the dip of these Wenlock rocks is far greater than that of the neighbouring Old Red Sandstone, rendering a conformable passage from Silurian to Old Red Sandstone improbable. No trace has been found of a Ludlow fauna.

(2) That the dip of the Wenlock rocks is such that they clearly overlie the andesite of Moon's Hill. The general succession of Silurian rocks in the Eastern Mendips is therefore as follows :—

Wenlock	Mudstone often very fossiliferous, with subordinate bands of highly micaceous sandstone exposed in the rail cuttings and by trenching in the fields to the S.E. of the Moon's Hill quarry. Thickness not ascertainable.	
	Pyroxene andesite of Moon's Hill, Sunnyhill, and Downhead quarries. In each case some tuff is interbedded with the andesite. Thickness probably not less than	500 ft.
Llandovery	Tuff, coarse and fine, exposed in Sunnyhill quarry and by trenching at Tadhill and Downhead, about	110 ft. seen

No further information has been obtained regarding the peculiar 'coarse ashy conglomerate' referred to in the above papers.

3. *The Glaciation of the North-East of Ireland.*
By ARTHUR R. DWERRYHOUSE, *D.Sc., F.G.S.*

The district under consideration consists of the Basaltic Plateau of County Antrim, the Silurian Uplands of County Down, the granitic Mourne Mountains, and the Valleys of the Bann and the Lagan, the former including the Lough Neagh Basin.

That the area was overridden by Scottish ice at the period of maximum glaciation has been known for some time, the Riebeckite-Eurite of Ailsa Craig being found in the boulder-clay and gravels, but the glaciation has not hitherto been worked out in detail, with the exception of that of the Belfast district, of which the Geological Survey has published a drift map.

At the period of maximum glaciation the country east of Lough Foyle, the Sperrin Mountains, and Slieve Gallion was completely covered by the Scottish ice, most of which travelled down the Firth of Clyde, and is here spoken of as the Firth of Clyde Glacier.

During the period of retreat the Firth of Clyde Glacier impounded the drainage of the district, and brought about the formation of a number of lakes, the overflow channels of which, 'dry gaps,' mark the various stages in the shrinkage of the ice.

The earliest channels appear to be on the north-western flanks of the Mourne Mountains at an elevation of about 1,200 feet, with others at lesser altitudes, one of the largest being between Corlieve Mountain and Tievedockaragh at 684 feet above sea-level.

As the ice-margin shrank northwards numerous 'dry gaps' were produced along the lower slopes of the Mournes and also through the granite hills of the Slieve Croob Range to the North.

Numerous other series of channels can be traced, produced as the ice-front fell back, a most interesting stage being reached when the Antrim Plateau was free from ice except along its seaward margin. The Valleys of the Bann and Lagan were closed near their mouths, and the then more extensive Lough Neagh drained through the now streamless valley at Poyntzpass to Newry and so into Carlingford Lough, and at another stage by Monaghan, Smithborough, and Clones into the Valley of the Erne. Still later, Lough Neagh, which was then continuous with the Lake Belfast of the Geological Survey, drained through the Dundonald Valley from Belfast to Newtownards and so into Strangford Lough.

The effects of the Firth of Clyde Glacier are to be seen in the presence of erratics from Ailsa Craig and Arran, some of the latter having been recognised by Mr. B. N. Peach when going over the ground with the writer in the uplift of boulders and in the transport of local erratics.

Many examples of the diversion of rivers by morainic material also occur, the most interesting being those of the Bush River near Armoy and the Glenaan River near Cushendall.

It has been stated that the Antrim Plateau was glaciated by local ice after the retreat of the Firth of Clyde Glacier, but the writer has failed to find any direct evidence of this in the northern part of the area, though the valleys of the Sperrin Mountains to the west were occupied by local glaciers.

4. *The Glacial Period and Climatic Changes in North-East Africa.*
By W. F. HUME, *D.Sc., F.R.S.E., and* J. I. CRAIG, *M.A., F.R.S.E.*

1. *Southerly Shift of the Wind systems in Glacial Times.*—The effect of the seasonal decrease of temperature in the Northern hemisphere is to cause a seasonal displacement of the system of westerly moist winds southwards by several degrees, and not improbably decrease of temperature below its normal is also associated with a similar displacement. It is inferred that the decrease of temperature of the Glacial Period would be correlated with such a displacement of the westerly winds, which now barely touch the north coast of Egypt in winter, that they would impinge on the loftiest portion of the Red Sea mountain range.

Geological and topographical evidence points conclusively to the existence of such a westerly moist current at no very distant period. The current was

westerly, for the principal erosion occurred on the western slopes, and this erosion is evidenced by the gravel terraces, which attain a remarkable development near the town of Qena. These consist of materials which could have come only from the highest portion of the Red Sea Hills, distant some 40 to 50 miles to the east or north-east. The precipitation was most active where the range is highest, and decreases towards the north where the mountains are lower. The decrease towards the south is to be attributed more probably to an approach to the southern limit of the moist current.

Further evidences of such a westerly current are to be found in the existence of calcareous tufas on the border of the eastern scarp of Kharga Oasis and elsewhere; and that the temperature was then several degrees colder is shown by the presence in the tufas of leaf-fragments of *Quercus ilex* and other plants which do not now flourish south of Corsica and southern France.

2. *Change in Monsoon Effects during the Glacial Period.*—There is evidence of the enormous development of glaciers over Ruwenzori, Mount Kenia, Kilimanjaro, and the Himalayas, during the Glacial Period. The recession of the glaciers in East Africa indicates that the temperature there is now about 10° to 12° F. warmer than during the period of maximum glaciation.

It is known from the investigations of the Meteorological Department of India that an increased snowfall on the Himalayas in spring exercises a measurable prejudicial effect on the Indian monsoon at the present day, and we may infer that the enormously greater ice-covering of the Glacial Period would exercise a much more powerful inhibition on the monsoon of that period. The more extensive ice-sheet of East Africa, by preventing abnormal heating of the land in summer, would act still further in the same direction, and it is extremely probable that the monsoon current partook of the southerly displacement of the wind system referred to above. The general result would be a decreased precipitation over Abyssinia, and a much reduced Sobat, Blue Nile, and Atbara, which at present account for 96 per cent. of the flood proper of the Nile.

The geological history of the Nile entirely accords with the above inferences. One of the chief results of the present monsoon rainfall has been the deposit of finely divided muds, brought from the Abyssinian hills, in the Nile valley. To the south of Cairo these deposits are at most of 30 to 35 feet thickness, of which 10 feet have been laid down since the time of Ramses II. If conditions have remained uniform, this would give a date fourteen thousand years ago for the first deposits of alluvial muds in Egypt. Previous to this the mud-laden waters of the Abyssinian Nile system did not reach Egypt, as the waters of Khor Gash now fail to reach the Nile, and so geology and meteorology concur in indicating a much weaker rainfall in Abyssinia during the Glacial Period.

5. *Interim Report of the Geological Photographs Committee.*

6. *Report on the Preparation of a List of Characteristic Fossils.*

See Reports, p. 118.

7. *Report on the Erratic Blocks of the British Isles.*

See Reports, p. 101.

8. *Report on the Igneous and Associated Rocks of the Glensaul and Lough Nafooey Areas, Cos. Mayo and Galway.*

See Reports, p. 101.

FRIDAY, SEPTEMBER 1.

The following Papers were read :—

1. *Joint Discussion with Section E on the former Connection of the Isle of Wight with the Mainland. Opened by* CLEMENT REID, *F.R.S.*

The origin of the winding channel which separates the Isle of Wight from the mainland has led to much speculation, and geographers and geologists have met to-day to discuss this question.

Unfortunately, it was only two days ago that I was asked to open the debate, and I have thus been unable to refer to my notes of what early writers have said as to the mode by which this winding channel was formed and the island cut off. But, briefly, the early opinions were these: A hundred years ago and more valleys of this sort were commonly referred to some convulsion of Nature, which formed a wide rift, cutting off an island by a channel of uniform width, and the width of the channel showed how much the island had been shifted laterally. At the present day there is no need to discuss any such hypothesis.

Somewhat later, channels like the Solent were referred to the eroding action of the sea and tide. But this hypothesis also breaks down as soon as we make a careful examination of the shores of the Solent, of its tides, and of their scour. The sea is neither cutting nor widening the Solent, and except in the parts where the waves of the open sea can reach, there is a great tendency to silt up and form wide tracts of salt-marsh or shingle.

The third hypothesis, which is commonly accepted at the present day, is that the Solent is a submerged river-valley which has been cut into laterally by the sea and thus isolated. But opinions differ as to the direction in which this river flowed. Did it come from the east or from the west?

I am going to maintain that the ancient River Solent indubitably flowed from the west, and not only so, but that at one time it was one of the largest rivers in England, comparable in drainage area, and also in its relation to the geological structure, with the Thames.

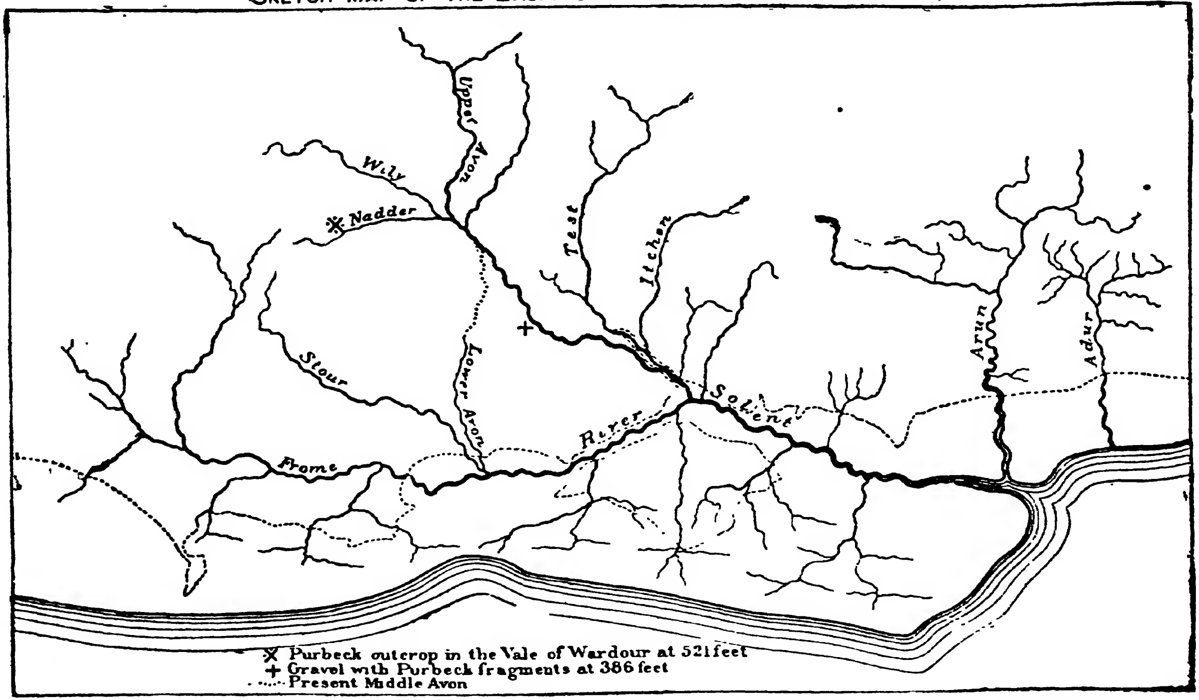
If we stand on one of the hills near Portsmouth or on the central down of the Isle of Wight we see at once that we are dealing with a very wide river-valley. On either side of the Solent or Spithead sheets and terraces of subangular river-gravel slope up and up to a height of at least 400 feet above the sea, though in the centre of the valley they pass actually beneath the present sea-level. Now these gravels have a very peculiar composition, and by tracing the stones toward their source we can arrive at some very surprising conclusions as to the direction of the flow of the ancient River Solent. Leaving out of account the ice-carried erratics, which in this part of England seem never to have been stranded more than 50 feet above the sea, we find that the gravels at higher levels are full of greensand-chert and contain fragments of Palæozoic rocks belonging originally to the West Country.

For a good many years the gravels puzzled me, for the old idea that the cherts came from the central axis of the Weald would not account for the other stones, which certainly could not have come from that district. But gradually some fifteen or twenty years' work at the geological maps of Hampshire, Sussex, and Dorset enabled us to trace the stones to their sources, and slowly was unfolded one of the most beautiful examples of river-development and river-destruction I have come across.

The general result of this work is shown on the accompanying map, copied from one published by me in the Ringwood Memoir of the Geological Survey. It was not till I had worked westward into Dorset and Wiltshire that I realised how important a river the ancient Solent had been.

I will try briefly to follow the ancient river from its mouth to its source, or, rather, sources, for it was a river of many heads draining an extensive area. The map shows approximately its course; though minor details, when more closely studied, may need modification. On the map I have attempted to reconstruct this river-system for a definite date. When first earth-movements formed the Tertiary basins of Hampshire and London, each of these basins—

SKETCH-MAP OF THE BASIN OF THE ANCIENT RIVER SOLENT.



[*From Memoirs of the Geological Survey, Ringwood.* *By permission of the Controller of His Majesty's Stationery Office.*]

which are very similar and both closed by harder rocks on the west—was occupied by an eastward-flowing river, the Thames and the Solent. The valley of the Thames seems merely to have deepened, retaining all along approximately its original course. The valley of the Solent, on the other hand, ran for some distance parallel to the sea-coast, and at no great distance from it: the result of which was that the sea finally broke through the narrow ridge of chalk which once ran continuously from the Needles to the Dorset coast, thus diverting the Frome and all the western rivers from their course to the Solent and isolating the Isle of Wight. This flank attack had still other effects. The Lower Avon, instead of having a fall of many miles before reaching the sea somewhere near Portsmouth, was shortened and reached the sea by a steep direct course. Consequently, as the river flowed over loose Tertiary strata, it lowered its bed so rapidly as to cut back its valley and capture the whole drainage of Salisbury Plain, which previously had followed its natural course south eastward and flowed into Southampton Water.

To some these ideas may seem highly speculative; but I had the good fortune to discover clear evidence of this diversion. Among other things I found that the high-level river-gravels of the Vale of Wardour, containing very peculiar fossiliferous Purbeck-cherts derived from an outcrop at 521 feet, went straight across the present Avon Valley and were found on its east side at a height of 380 feet; thus showing that when the rivers which meet at Salisbury flowed at a level some 300 feet higher than now they were tributaries of Southampton Water.

Thus by the diversion of these streams the great river Solent had its head waters cut off and was divided into several separate river-basins, each with its own outlet. This happened, I believe, in late Pliocene times.

These flank attacks are still going on further west, and if they continue much longer the breach at Lulworth Cove may widen and deepen in the same way; so that with slight submergence the so-called Isle of Purbeck may become a true island, exactly comparable in its geological structure and mode of origin with the Isle of Wight.

Though at this early date the Isle of Wight was cut off from the mainland, it was probably at first only cut off by a small stream and marshes, and was sometimes an island, sometimes part of the mainland, as the sea-level varied.

The final isolation took place at quite a recent period, for if Professor Ridgeway and I are right, the Isle of Wight is the Ictis and Vectis of classical writers, to which the ancients traded for tin. The island of Ictis is described as being cut off at high tide, but connected at low tide by a narrow stone causeway. This causeway, I believe, was the ridge of Bembridge Limestone which swept across what is now the Solent from Yarmouth to Hurst Castle, and was intact about two thousand years ago. It has now been destroyed by the attacks of the sea, and was apparently impassable even during the Roman occupation, for the Roman roads seem to have led to a ferry further east and out of the run of the sea.

Thus geology and history join hands, and geology helps us to understand the origin of one of the most important harbours of the world. The Solent, Spithead, and Southampton Water are parts of an ancient submerged valley-system The magnificent waterways thus formed are now slowly silting up, but that the process is not more rapid is due to the happy accident which diverted so much of the drainage of the ancient Solent to the open sea. Had it been otherwise, instead of the present fine harbours round Portsmouth we should have had a series of alluvial flats and sand-banks such as now block the lower reaches of the Thames.

2. *Constructive Waterfalls. By* Professor J. W. GREGORY, *F.R.S.* See Section E, p. 445.

3. *Tidal Movements of the Deep Water of the Skagerrak, and their Influence upon the Herring Fishery. By* Professor O. PETTERSSON.—See Section E, p. 446.

MONDAY, SEPTEMBER 4.

Joint Discussion with Sections E and K on the Relation of the present Plant Population of the British Isles to the Glacial Period.—See p. 573.

The following Papers were then read :—

1. *On the Lower Carboniferous Strata of the Bundoran District in South Donegal.* By W. B. Wright.

[Published by permission of the Director of the Geological Society of Ireland.]

In the month of March in the present year an attempt was made by the writer on behalf of the Geological Survey to get some evidence of the palæontological horizon of the Lower Carboniferous strata of the North-West of Ireland. The district about Bundoran, on the borders of Donegal, Leitrim, and Sligo, was selected as representative and well exposed. Fossils were collected on the various horizons and sent to Messrs. G. W. Lee, R. G. Carruthers, and Ivor Thomas, of the Geological Survey of Great Britain, who kindly undertook to deal with the material obtained. It will of course be understood that to their expert knowledge the result is for the most part due

The lithological subdivisions of the Lower Carboniferous strata in the Bundoran district are summarised in the following table . —

	Feet
Millstone Grit (so-called)	- -
Yoredale Shales (so-called)	at least 500
Yoredale Sandstones (so-called)	300 to 400
Upper Limestone	about 500
Upper Calp Shale	1,100
Calp Sandstone	500 to 800
Lower Calp Shale	300 to 500
Lower Limestone	500 to 1,000

The Lower Limestone has a conglomeratic base resting on the gneiss; the Lower Limestone shale, so constantly present at the base of the limestone in other parts of Ireland where the Carboniferous strata pass down conformably into the Old Red Sandstone, is completely absent.

The species of brachiopods obtained from the various fossiliferous horizons of this series all indicate, according to Messrs. Lee and Thomas, Lower and Middle Visean horizons (say C and S of Vaughan's classification). There is no indication of any Tournaisian beds whatever. Neither is there any indication at the top of the series of Upper Visean beds (D zone) The beds which have hitherto been known as 'Yoredale Shales' yield the characteristic Pendleside fossil *Posidonomya becheri*, but this is associated with a cephalopod fauna which is not that of the Pendleside Series of England but of the main mass of limestone beneath the Pendlesides of Hind.

The corals, although found in great numbers, yielded less definite results, but, so far as they go, they indicate in the opinion of Mr. Carruthers an abnormal phase of the Lower and Middle Visean, peculiarly rich in zaphrented and other small corals. There is a complete absence of the typical Tournaisian forms *Zaphrentis delanouei* and *Z. konincki*, and no specimens were observed of such characteristic 'D' corals as *Lithostrotion junceum*, the Lonsdaleoids or the Dibunophylla.

The conclusion drawn from a study of the fauna, that the Carboniferous strata of Bundoran are throughout of Visean age, leads to an interesting stratigraphical result, for it establishes palæontologically for this area the transgression invoked by Jukes on purely lithological grounds to account for the

anomalies of the Lower Carboniferous series in various parts of Ireland. It shows, moreover, that this transgression reached the Bundoran district about the end of the Tournaisian or the beginning of Visean times.

2. *On the Occurrence of Submerged Forests in certain Lakes in Donegal and the Western Isles of Scotland.* *By* W. B. WRIGHT.

[Published by permission of the Director of the Geological Survey of Ireland.]

The author called attention to the existence in a number of inland lakes in South Donegal and the Western Isles of Scotland of submerged pine-tree stools in the position of growth. They occur at a level several feet beneath that of the outlet, which, being in many cases over broken rock or boulder-clay, precludes any explanation of a rise in the water-level due to peat growth. These cases are unquestionably similar to some described of recent years in Sweden, and the author inclines to the view that they are actually the results of a drier climate, during which the lakes rarely, if ever, had any overflow. He points out, however, the need of caution in drawing this conclusion, as the mere presence of forests in the catchment basin might, by checking drainage and promoting transpiration, have in itself caused the partial drying up of the lakes.

3. *On some new Rhætic Fossils from Glen Parva, Leicestershire.* *By* A. R. HORWOOD.

Owing to the impending filling up of the once fine pit at Wigston (Glen Parva), where the Keuper tea-green marl, rhætic, and Lias formations are all exposed in a fine section of some 80 feet of rock, extraordinary efforts have been made by Messrs. A. J. Cannon and H. Siddons to investigate the contents of the bone-bed and black shales of the rhætic before this is rendered impossible by the filling up of the pit with water, the brick-yard being now closed.

Some rare and new fossils have been found which may here be briefly mentioned. In the tea green marls *Orbiculoidea townsendi* was discovered. This, along with the regular occurrence there of bands of fish scales and teeth in the same beds, and of *Estheria minuta*, allies them palæontologically with the rhætic beds in which alone the first fossil has hitherto been found.

In the succeeding black shales amongst many plant fragments are some leaves allied to *Podozamites*, which are new. An exceedingly interesting discovery is the impression, unique as such for Palæozoic or Mesozoic rocks, of an annelid which occurs in beds filled with castings allied to *Arenicola*. Amongst Arthropodous remains are the chitinous body-segments of crustacea and a scorpion-like creature. That they are not uncommon elsewhere is probable. But the rhætic fauna is so fragmentary and generally so depauperate and stunted that the most careful search is required.

Ophiolepis damesii, not definitely found *in situ* here before, has occurred, and with it some other echinoderms which may be new. Many fine examples of *Pholidophorus higginsi* have been secured which exhibit the dermal armature well, and also the fins. Some curious concretionary structures, homœomorphs of orthoceratoid segments, occur here also. The usual fauna already described has been obtained, some fine examples of each species having been collected. It is hoped to describe the new forms very shortly.

4. *On the Shell-layer in Mollusca.* *By* A. R. HORWOOD.

Although most biologists, and many palæontologists, *e.g.*, Hyatt, have recognised that Mollusca, fossil or recent, possessed shells of more than one layer, yet in speaking of the layers of fossil shells almost exclusively hitherto the shell has been regarded as either aragonite or calcite, as though consisting of but *one*

layer. In the case of Cephalopoda and Lamellibranchiata in the living shell there are two and three layers: hence it is inconceivable the above usage should have become general in the face of this knowledge. As a result of recent examinations of the main genera of fossil Mollusca, the following table may be given, showing the number of layers and their mineral state, for comparison with living genera as given by Sorby[1]:—

Sub-phyla	Living	Fossil
Gasteropoda	1. *Only layer.*—Aragonite with chitinous substance (conchiolin) rarely sulphate of lime	1. *Only layer.*—Aragonite usually found as tests, but sometimes as aragonite, sometimes granular calcite.
Lamellibranchiata	1. Dark horny conchiolin 2. Outer calcareous prismatic layer, calcite 3. Inner layer, lamellar porcellanous aragonite	1. Absent. 2. Calcite. 3. Aragonite, usually pseudocalcite.
Cephalopoda	1. Black layer 2. Porcellanous laminar aragonite 3. Nacreous calcite.	1. Black layer (rare). 2. Aragonite. 3. Calcite.

Owing to the common occurrence of shells in the form of casts, or with the aragonite layer transformed into calcite, or unaffected, several states occur which, in writing of them for comparative purposes, need separate terms for sake of conciseness and reference. These are given in tabular form:—

Terms	Layer	Condition or Age
Calcite	Inner	Living types.
Aragonite	Outer	,, ,,
Authocalcite	Inner	Fossil, unaltered.
Mesauthocalcite	Middle	,, ,,
Autharagonite	Outer	,, ,,
Pseudocalcite	Outer	Fossil, altered.
Mesopseudocalcite	Middle	,, ,,
Atestous cast	Inner or Outer	Absent.
'Black layer'	Third layer	Living or Fossil.
Epidermis or periostracum	,,	Living (rare in Fossil state).

The rare preservation of aragonite as shell substance in rocks of Jurassic age is borne out by examination of typical types. Though of more frequent occurrence in some localities in Tertiary times it is of still less frequent occurrence in the intervening Cretaceous period, when calcite formation was more prevalent.

It is hoped the distinction here made for the first time between the different layers of the Molluscan shell, along with the difference in the mineral characters of each, may contribute to a better understanding of the biological significance of the different layers.

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[1] *Q.J.G.S.*, 1879.

TUESDAY, SEPTEMBER 5.

The following Papers and Reports were read:—

1. *On the Discovery of Remains of* Iguanodon mantelli *in the Wealden Beds of Brightstone Bay, I.W., and the Adaptation of the Pelvic Girdle in relation to an Erect Position and Bipedal Progression. By* R. W. HOOLEY.

The specimen of which the paper treated was discovered by the author in 1899; it includes the sacrum, lumbar and caudal vertebræ, bones of the pelvic girdle and the left femur. The characters shown by the fossil prove the remains to belong to *Iguanodon mantelli*, but all examples hitherto found have manifested this species to be much smaller than *Iguanodon bernissartensis*, whereas the bones discovered belonged to a reptile equalling, if not exceeding, the dimensions of that species. Among the skeletons of Iguanodons found at Bernissart in 1878, M. Dollo found a small and a large form. The former resembled in all points the type specimen of *Iguanodon mantelli*, and he thought that the differences between the two forms were specific and not sexual. This specimen opens the question again, and the author criticised the evidence, and inclined to the opinion that the osteological variations are sexual, and that *Iguanodon bernissartensis* is probably a synonym of *Iguanodon mantelli.*

The second part of the paper dealt with the adaptation of the Iguanodont pelvis to enable an upright position and progression, and discussed the variations in the Dinosaurian pelvis.

2. *Siliceous Oölites and other Concretionary Structures in the Vicinity of State College, Pennsylvania. By* Professor E. S. MOORE, *M.A., Ph.D.*

The area under discussion is situated in central Pennsylvania, on the border of the Appalachian mountain system. The rocks comprise a complex series of impure limestone and sandstone, regarded as a transition between the Cambrian and Ordovician, a large limestone group of Ordovician age, and several hundred feet of Silurian sandstone.

The concretions occur very largely in the transition series, and include calcareous and siliceous oölites and bodies consisting of chert, flint, or limonite, the last forming beds of iron ore by replacement of arenaceous limestone.

The oolites form thin and irregular beds, covering an area of over forty square miles. The calcareous variety probably owes its origin to a mixture of sand grains and calcium carbonate and to the fact that there were frequent alternations from a condition of deposition of limestone to a disintegration, solution, and redeposition of this rock. The evidence for this conclusion is found in the fact that the oölites occur in a complex mixture of calcareous sandstone and limestone with alternations to thin beds of limestone-conglomerate and also that sand grains or fragments of carbonate usually form the nuclei of the concretions. The siliceous oölites originated by replacement of the calcareous concretions because they occur together, and the former grade into the latter.

There is evidence to show that the source of the silica is to be found in chert nodules and in the sand grains occurring in the limestone. The chief solvents for the silica are believed to have been organic acids and meteoric waters.

In conclusion, certain similarities between the physical characters and origin of concretions and crystals are suggested.

3. *The Pre-Cambrian Beds of Northern Ontario.*
By Professor E. S. MOORE, *M.A., Ph.D.*

A discussion of the pre-Cambrian beds of Northern Ontario in a limited time must be extremely general and be lacking in detailed descriptions of any of the complicated features which characterise these beds. While therefore thankfully acknowledging all information received from other workers on the problems

of the region, the writer confined himself to conclusions which he has reached as a result of field work.

The region presents a surface which is almost a peneplain, and over the larger part of which there are no rocks exposed younger than pre-Cambrian, except the Pleistocene drift which occurs everywhere. While there have been some oscillations of the 'Canadian Shield' so as to allow, in places, the deposition of Palæozoic limestone beds, remnants of which are still found between Lake Ontario and Hudson Bay, it is probable that considerable portions of the 'Shield' have not been beneath the sea since pre-Cambrian time, and possibly not since the earlier periods of that great age. The classification of the rocks most applicable to the areas north and north-west of Lake Superior is as follows :—

Cenozoic . .	Recent . . .	Alluvial deposits and travertine.
	Pleistocene .	Drift and glacial lake deposits.
Pre-Cambrian .	Keweenawan	Sediments including red shales, dolomites, sandstones, and conglomerates.
		Igneous rocks very prominent and mostly diabase, but also norite, gabbro, and peridotite.
	Huronian . .	Upper H. (Animikie); red and black shales, quartzite, and iron ore.
		Middle H. absent.
		Lower H.; basal conglomerate graywacké, quartzite iron-formation, and probably some limestone.
	Laurentian .	Great acid igneous series consisting of granite, gneiss, and some grano-diorite.
	Keewatin . .	Green and grey schists derived by metamorphism of any of the other Keewatin rocks.
		Banded iron-formation and a little limestone.
		Graywacké and grey schists or fine-grained gneisses.
		Acid eruptives, including quartz porphyries, rhyolites, and acid tuffs.
		Basic and intermediate eruptives, including amygdaloidal and ellipsoidal basalt, diabase, gabbro, diorite, andesite, and tuffs.

The Keewatin system is an extremely complex one. As a rule the great acid eruptions took place after the basic, but the order is very complicated. The graywacké is apparently the result of disintegration and incomplete sorting, probably under subaerial conditions, of the basic igneous rocks, while the grey, fine-grained gneisses are regarded as the result of similar changes in the acid rocks. The iron-formation is supposed to have been formed by the leaching out of the iron from the basic rocks and its collection in the depressions existing on the irregular volcanic surface. It is almost always interbedded with other sediments such as graywacké or carbonaceous shale.

The close of the Keewatin was marked by great diastrophism folding the rocks along axes running approximately east-north-east by west-south-west, and under the anticlines arose the great batholiths of Laurentian granite now generally altered to gneiss. This plutonic rock has been exposed by erosion over immense areas, and is a very barren type from an economic standpoint, possibly because it cooled under uniform conditions, and as a rule lacks differentiation. To avoid confusion it was thought advisable to restrict the term Laurentian to those granites and gneisses which may be identified as originating at the close of the Keewatin and before the laying down of the Huronian conglomerate, instead of applying it also to certain acid igneous rocks which possess certain textural characters, as is done by some geologists. Following the upheaval at the close of the Keewatin which set the streams actively to work, there was a great base-levelling which cut well down into the plutonic rocks under the anticlines, and the materials derived formed the great basal conglomerate of the Lower Huronian, which in some places at least contains beds of glacial boulders. The coarser sediments were succeeded by finer-grained types such as graywacké, sandstone, and probably in a few cases by limestone, as a few small areas of the latter rock have been found in this area, though it is difficult to settle their exact stratigraphical position. The

Huronian period was also marked by considerable igneous activity. The Middle Huronian has not been found in the regions in which the writer has done much field work, and the Animikie, on the north shore of Lake Superior, seems to be more closely related to the Keweenawan than to the Huronian. In the Keweenawan period the vicinity of Lake Superior was the centre of a region of great igneous activity, and immense sheets of diabase were intruded into the previously formed Animikie and Keweenawan sediments. Much of the Keweenawan igneous rock must be classified, like the Laurentian and Keewatin, largely on a lithological basis, as in many sections there is absolutely no fixed sedimentary horizon in the whole geological scale from Keewatin to Recent. The Keweenawan diabase sills usually have a columnar structure, and in a few places show evidences of differentiation of the magma.

The writer has never found a distinct fossil in the pre-Cambrian, but he would infer that life existed even back in the Keewatin, because of the presence of limestone, carbonaceous shales, and iron ore, some of which seems to be of bog origin, and also because the more evidence which is collected the more it points to the existence of conditions not unlike those over much of the earth at the present time.

4. *On the Occurrence of a Freshwater Limestone in the Lower Eocenes on the Northern Flank of the Thames Basin.* *By* A. IRVING, *D.Sc., B.A.*

The limestone was first met with in a well-section at Thorley, on the Herts border. In three other well-sections in the Bishop's Stortford district the same limestone occurs, and in all three of these the limestone is duplicated. These freshwater limestones (often containing traces of freshwater plants) are interbedded with the dirty quartzose sands characteristic of the Woolwich and Reading series over a large area, where they are overlain by the pre-glacial stratified gravels, or are proved in other places to underlie the true basement bed of the London Clay with black flint pebbles, oysters, and sharks' teeth These facts seem to justify Prestwich's classification of the Oldhaven Beds as belonging stratigraphically to the Woolwich and Reading Beds rather than to the London Clay above; and to show that Whitaker's contention[1] that 'the series is clearly separable from the Woolwich Beds below cannot be sustained.' The fossils contained in the limestone were recognised by Professor McKenny Hughes as a series belonging to the *Oldhaven Beds,* and afterwards named by Messrs. F. R. C. Reed and W. Keeping at the Sedgwick Museum.

Fossils from the Thorley Well.

Chenopus (Aparrhais) Sowerbyi.
Cardium Laytoni.
Cyprina Morrisi.
Cyrena cuneiformis (?)
Cyrena strigosa or *cordata*(?) (young).
Psammobia (?) sp.
Cytherea (?) sp.

We seem to be here on a rough north to south zone of the Tamisian area marked by a coalescence of the conditions under which the typical Thanet Sands (further east) and the typical Reading Beds (further west) were laid down. The absence of the London Clay between the Boulder Clay and these Reading Beds over a considerable distance is somewhat remarkable, as pointing to prequaternary denudation.

5. *A remarkable Sarsen or Greywether.*[2] *By* A. IRVING, *D.Sc., B.A.*

Without desiring to add to the existing plethora of literature on these rocks the author thinks that this sarsen is worth special notice. It was discovered last winter in digging a grave in the Bishop's Stortford Town Cemetery about seven feet from the surface in the principal boulder clay of the district, the equivalent of the chalky boulder clay of the Eastern Counties. It has been placed in the grounds of Hockerill Vicarage.

[1] *Mem. Geol. Surv.*, iv., p. 239.

[2] A popular account of this block was given by the author in the *Herts and Essex Observer,* January 7, 1911.

The block is fairly angular, approximately a cube. On one side the fracture of the bed is fairly fresh; the opposite side is slightly hollowed, as if by the long-continued current action of a shingly stream. For the greater part of its thickness it is a true sarsen; towards the base a few flint pebbles are scattered through it; the upper surface passes into a true 'puddingstone' (an agglutinated mass of flint pebbles), the matrix of which is lithologically the same as, and continuous with, the material of the sarsen. About the middle of the upper side the agglutinated mass of pebbles fills a small gully in the *quondam* sand of the sarsen (three photographs shown). A subordinate alternation of the true sarsen structure with the pebble-bed structure is seen in the largest examples of puddingstone perhaps in the county.[1] A striking lithological feature of this specimen is the distribution in it of numerous small angular bleached fragments of flint. Its dimensions are 30 inches × 20 inches × 18 inches, and its weight not less than half a ton. No trace of glacial striations has been detected on it.

The author refers to his former work on the genesis and distribution of the sarsens.[2] While recognising their common occurrence in the Lower Eocenes, and even in the sands of the Neocomian, he regards those of the interior of the London Basin as the wreckage of a younger formation (late Eocene or Oligocene), possibly the stratigraphical freshwater equivalents of the *Stettiner Sandstein* of North Germany[3] and the *Grès de Fontainebleau*[4] of the Paris Basin. Agglutinated portions of the Bagshot Pebble Beds *in situ*, with similar siliceous cementation, are known to occur;[5] there is good evidence of the quondam extension of the younger beds of the Bagshot Series (including the pebble beds) over Herts and Essex; and the author points to this recently unearthed rock-mass as tending to clinch the view advocated by him for years past—that the sarsens and the Herts 'puddingstone' are remnants of one and the same *younger* Eocene (or Oligocene) formation.[6] He considers the latest treatment of the subject by the late Professor T. Rupert Jones, F.R.S., and the more recent treatment of it by H. B. Woodward, F.R.S.,[7] inadequate.

6. *Wealden Ostracoda.* *By* F. Ross Thomson.

This paper was intended to describe and illustrate the Ostracoda of the Wealden formation, as they have never before been thoroughly investigated.

Those of the Purbeck formation have been worked out by the late Professor Rupert Jones, and in his paper on the subject, published in the 'Quarterly Journal of the Geological Society,' he stated that he hoped to be able to treat in full the Wealden Ostracoda at a future opportunity, but his intention was unfortunately never carried out.

He gave a list of the fossils common to the Purbeck and Walden so far as he was able to do so at the time he wrote, viz., in 1885, but his list as regards the Wealden appears to be inaccurate and incomplete, and the object of this paper was to classify and bring up to date what he had left undone.

It was pointed out that the principal Wealden form, *Cyprus Valdensis*, is triangular and bean-shaped, and does not possess the antero-ventral notch so common to other forms, but Fitton, Rupert Jones, and the German geologists, Dunker and Roemer, seem to have mistaken *Cypridea punctata* for this fossil.

A full list and detailed description of those forms that have now been found to belong to the Wealden formation were given, and photographs of them in the matrix were shown.

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[1] Seen in the grounds of Oak Hall, Bishop's Stortford (G. E. Pritchett, Esq., F.S.A., who has furnished photographs).

[2] *P. G. A.*, viii., No. 3 (1883), where critical reference is made to the views of the late Professor John Phillips, F.R.S., of Oxford.

[3] H. Credner: *Géologie* (Leipzig), 10th ed., pp. 692 ff.

[4] S. Meunier: *Les causes actuelles en Géologie* (p. 289); Credner (*op. cit.*), p. 683.

[5] A. Irving: *P. G. A.*, xv. (February 1898), pp. 196, 236.

[6] A. Irving: 'High Level Plateau Gravels, &c.,' *Geol. Mag.*, No. 484, October 1904.

[7] 'The Geology of the London District,' *Mem. Geol. Surv.*, 1909.

7. *The First Meteorite Record in Egypt.*
By W. F. Hume, *D.Sc., F.R.S.E.*

The fall of the first meteorite hitherto recorded from Egypt took place between 6 and 9 A.M. on June 28, 1911, in the neighbourhood of El Nakhla village, seven kilometres N.N.E. of Abu Hoomos station, which is 44 kilometres E.S.E. of Alexandria, on the Alexandria-Cairo Railway line. A personal visit was paid to the locality, and the numerous witnesses examined as to the nature of the phenomena observed. All accounts agree that the stones fell out of a clear sky from the north-west, appearing as a white cloud variously estimated from one to three metres long. At Ezbot Abdalla Zeid, near Nakahla, the meteorite exploded several times, breaking up into several fragments, the fall being also accompanied by a thunderclap, followed by a whistling or buzzing sound.

Numerous specimens were obtained from localities lying on a north-south line whose extreme points were separated about a mile and a half from one another. These are all characterised by an intense black and highly polished varnish of iron oxide, coating a green granular rock mainly composed of augite and hypersthene, the specific gravity being 3·4. The largest specimen weighs 1·813 kilogram, having a total length of 16 cm., a width of 8 cm., and a height of 7 cm.; its general form being a double wedge. In several examples the varnish tends to be of radiate structure in the shallow pittings which cover the whole surface, and the edges are rounded, showing intense fusion. Nevertheless, as is usual in such cases, the meteorites are stated to have been cold when picked up.

The original record of the occurrence was given in the 'El Ahali' newspaper, and referred to in the 'Egyptian Gazette,' as having occurred at Denshal, south of Damanhour, some fifteen miles from Nakhla. A fall at this locality has not, however, been hitherto confirmed, it being stated by those examined from this locality that an explosion resembling a clap of thunder was heard, but no stones were observed to fall.

8. *Report on the Composition and Origin of the Crystalline Rocks of Anglesey.* See Reports, p. 116.

9. *Report on the Excavation of Critical Sections in the Palæozoic Rocks of Wales and the West of England.*—See Reports, p. 111.

10. *Interim Reports on the Microscopical and Chemical Composition of Charnwood Rocks.*

11. *Report on the Fossil Flora and Fauna of the Midland Coalfields.*—See Reports, p. 105.

SECTION D.—ZOOLOGY.

PRESIDENT OF THE SECTION.—PROFESSOR D'ARCY W. THOMPSON, C.B.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

Magnalia Naturæ; or, The Greater Problems of Biology.

THE science of Zoology, all the more the incorporate science of Biology, is no simple affair, and from its earliest beginnings it has been a great and complex and many-sided thing. We can scarce get a broader view of it than from Aristotle, for no man has ever looked upon our science with a more far-seeing and comprehending eye. Aristotle was all things that we mean by 'naturalist' or 'biologist.' He was a student of the ways and doings of beast and bird and creeping thing; he was morphologist and embryologist; he had the keenest insight into physiological problems, though lacking that knowledge of the physical sciences without which physiology can go but a little way: he was the first and is the greatest of psychologists; and in the light of his genius biology merged in a great philosophy.

I do not for a moment suppose that the vast multitude of facts which Aristotle records were all, or even mostly, the fruit of his own immediate and independent observation. Before him were the Hippocratic and other schools of physicians and anatomists. Before him there were nameless and forgotten Fabres, Röesels, Réaumurs, and Hubers, who observed the habits, the diet, and the habitations of the sand-wasp or the mason-bee; who traced out the little lives, and discerned the vocal organs, of grasshopper and cicada; and who, together with generations of bee-keeping peasants, gathered up the lore and wisdom of the bee. There were fishermen skilled in all the cunning of their craft, who discussed the wanderings of tunny and mackerel, sword-fish or anchovy; who argued over the ages, the breeding-places and the food of this fish or that; who knew two thousand years before Johannes Müller how the smooth dogfish breeds; who saw how the male pipe-fish carries its young before Cavolini; and who had found the nest of the nest-building rock-fishes before Gerbe re-discovered it almost in our own day. There were curious students of the cuttle-fish (I sometimes imagine they may have been priests of that sea-born goddess to whom the creatures were sacred) who had diagnosed the species, recorded the habits, and dissected the anatomy of the group, even to the discovery of that strange hectocotylus arm that baffled Della Chiaje, Cuvier, and Koelliker, and that Verany and Heinrich Müller re-explained.

All this varied learning Aristotle gathered up and wove into his great web. But every here and there, in words that are unmistakably the master's own, we hear him speak of what are still the great problems and even the hidden mysteries of our science; of such things as the nature of variation, of the struggle for existence, of specific and generic differentiation of form, of the origin of the tissues, the problems of heredity, the mystery of sex, of the phenomena of

reproduction and growth, the characteristics of habit, instinct, and intelligence, and of the very meaning of Life itself. Amid all the maze of concrete facts that century after century keeps adding to our store these, and such as these, remain the great mysteries of natural science—the *Magnalia naturæ*, to borrow a great word from Bacon, who in his turn had borrowed it from St. Paul.

Not that these are the only great problems for the biologist, nor that there is even but a single class of great problems in Biology. For Bacon himself speaks of the *magnalia naturæ, quoad usus humanos*, the study of which has for its objects 'the prolongation of life or the retardation of age, the curing of diseases counted incurable, the mitigation of pain, the making of new species and transplanting of one species into another,' and so on through many more. Assuredly I have no need to remind you that a great feature of this generation of ours has been the way in which Biology has been justified of her children, in the work of those who have studied the *magnalia naturæ, quoad usus humanos*.

But so far are biologists from being nowadays engrossed in practical questions, in applied and technical Zoology, to the neglect of its more recondite problems, that there never was a time when men thought more deeply or laboured with greater zeal over the fundamental phenomena of living things; never a time when they reflected in a broader spirit over such questions as purposive adaptation, the harmonious working of the fabric of the body in relation to environment, and the interplay of all the creatures that people the earth; over the problems of heredity and variation; over the mysteries of sex, and the phenomena of generation and reproduction, by which phenomena, as the wise woman told, or reminded, Socrates, and as Harvey said again (and for that matter, as Coleridge said, and Weismann, but not quite so well)—by which, as the wise old woman said, we gain our glimpse of insight into eternity and immortality. These then, together with the problem of the Origin of Species, are indeed *magnalia naturæ*; and I take it that inquiry into these, deep and wide research specially directed to the solution of these, is characteristic of the spirit of our time, and is the pass-word of the younger generation of biologists.

Interwoven with this high aim which is manifested in the biological work of recent years is another tendency. It is the desire to bring to bear upon our science, in greater measure than before, the methods and results of the other sciences, both those that in the hierarchy of knowledge are set above and below and those that rank alongside of our own.

Before the great problems of which I have spoken, the cleft between Zoology and Botany fades away, for the same problems are common to the twin sciences. When the zoologist becomes a student not of the dead but of the living, of the vital processes of the cell rather than of the dry bones of the body, he becomes once more a physiologist, and the gulf between these two disciplines disappears. When he becomes a physiologist, he becomes, *ipso facto*, a student of chemistry and of physics. Even mathematics has been pressed into the service of the biologist, and the calculus of probabilities is not the only branch of mathematics to which he may usefully appeal.

The physiologist has long had as his distinguishing characteristic, giving his craft a rank superior to the sister branch of morphology, the fact that in his great field of work, and in all the routine of his experimental research, the methods of the physicist and the chemist, the lessons of the anatomist, and the experience of the physician are inextricably blended in one common central field of investigation and thought. But it is much more recently that the morphologist and embryologist have made use of the method of experiment, and of the aid of the physical and chemical sciences—even of the teachings of philosophy: all in order to probe into properties of the living organism that men were wont to take for granted, or to regard as beyond their reach, under a narrower interpretation of the business of the biologist. Driesch and Loeb and Roux are three among many men who have become eminent in this way in recent years, and their work we may take as typical of methods and aims such as those of which I speak. Driesch, both by careful experiment and by philosophic insight; Loeb, by his conception of the dynamics of the cell and by his marvellous demonstrations of chemical and mechanical fertilisation; Roux, with his theory of autodetermination, and by all the labours of the school of *Entwickelungsmechanik* which he has founded, have all in various ways, and from more or less different

points of view, helped to reconstruct and readjust our ideas of the relations of embryological processes, and hence of the phenomenon of life itself, on the one hand to physical causes (whether external to or latent in the mechanism of the cell), or on the other to the ancient conception of a Vital Element alien to the province of the physicist.

No small number of theories or hypotheses, that seemed for a time to have been established on ground as firm as that on which we tread, have been reopened in our day. The adequacy of natural selection to explain the whole of organic evolution has been assailed on many sides; the old fundamental subject of embryological debate between the evolutionists or preformationists (of the school of Malpighi, Haller, and Bonnet) and the advocates of epigenesis (the followers of Aristotle, of Harvey, of Caspar F. Wolff, and of Von Baer) is now discussed again, in altered language, but as a pressing question of the hour; the very foundations of the cell-theory have been scrutinised to decide (for instance) whether the segmented ovum, or even the complete organism, be a colony of quasi-independent cells, or a living unit in which cell differentiation is little more than a superficial phenomenon; the whole meaning, bearing, and philosophy of evolution has been discussed by Bergson on a plane to which neither Darwin nor Spencer ever attained; and the hypothesis of a Vital Principle, or vital element, that had lain in the background for near a hundred years, has come into men's mouths as a very real and urgent question, the greatest question for the biologist of all.

In all ages the mystery of organic form, the mystery of growth and reproduction, the mystery of thought and consciousness, the whole mystery of the complex phenomena of life, have seemed to the vast majority of men to call for description and explanation in terms alien to the language which we apply to inanimate things; though at all times there have been a few who sought, with the materialism of Democritus, Lucretius, or Giordano Bruno, to attribute most, or even all, of these phenomena to the category of physical causation.

For the first scientific exposition of Vitalism we must go back to Aristotle, and to his doctrine of the three parts of the tripartite Soul : according to which doctrine, in Milton's language, created things 'by gradual change sublimed, To vital spirits aspire, to animal, To intellectual!' The first and lowest of these three, the ψυχὴ ἡ θρεπτική, by whose agency nutrition is effected, is ἡ πρώτη ψυχή, the inseparable concomitant of Life itself. It is inherent in the plant as well as in the animal, and in the Linnæan aphorism, *Vegetabilia crescunt et vivunt*, its existence is admitted in a word. Under other aspects it is all but identical with the ψυχὴ αὐξητική and γεννητική, the soul of growth and of reproduction : and in this composite sense it is no other than Driesch's 'Entelechy,' the hypothetic natural agency that presides over the form and formation of the body. Just as Driesch's psychoid or psychoids, which are the basis of instinctive phenomena, of sensation, instinct, thought, reason, and all that directs that body which entelechy has formed, are no other than the αἰσθητική, whereby *animalia vivunt et sentiunt*, and the διανοητική, to which Aristotle ascribes the reasoning faculty of man. Save only that Driesch, like Darwin, would deny the restriction of νοῦς, or reasoning, to man alone, and would extend it to animals, it is clear, and Driesch himself admits,[1] that he accepts both the vitalism and the analysis of vitalism laid down by Aristotle.

The πνεῦμα of Galen, the *vis plastica*, the *vis vitæ formatrix*, of the older physiologists, the *Bildungstrieb* of Blumenbach, the *Lebenskraft* of Paracelsus, Stahl, and Treviranus, 'shaping the physical forces of the body to its own ends,' 'dreaming dimly in the grain of the promise of the full corn in the ear,'[2] these and many more, like Driesch's 'entelechy' of to day, are all conceptions under which successive generations strive to depict the something that separates the earthy from the living, the living from the dead. And John Hunter described

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[1] *Science and Philosophy of the Organism* (Gifford Lectures), ii., p. 83, 1908.

[2] *Cit.* Jenkinson (*Art.* 'Vitalism' in *Hibbert Journal*, April 1911), who has given me the following quotation : 'Das Weitzenkorn hat allerdings Bewusstsein dessen was in ihm ist und aus ihm werden kann, und träumt wirklich davon. Sein Bewusstsein und seine Träume mögen dunkel genug sein'; Treviranus, *Erscheinungen und Gesetze des organischen Lebens*, 1831.

his conception of it in words not very different from Driesch's, when he said that his principle, or agent, was independent of organisation, which yet it animates, sustains, and repairs; it was the same as Johannes Müller's conception of an innate 'unconscious idea.'

Even in the Middle Ages, long before Descartes, we can trace, if we interpret the language and the spirit of the time, an antithesis that, if not identical, is at least parallel to our alternative between vitalistic and mechanical hypotheses. For instance, Father Harper tells us that Suarez maintained, in opposition to St. Thomas, that in generation and development a Divine interference is postulated, by reason of the perfection of living beings; in opposition to St. Thomas, who (while invariably making an exception in the case of the human soul) urged that, since the existence of bodily and natural forms consists solely in their union with matter, the ordinary agencies which operate on matter sufficiently account for them.[1]

But in the history of modern science, or of modern physiology, it is of course to Descartes that we trace the origin of our mechanical hypotheses—to Descartes, who, imitating Archimedes, said, 'Give me matter and motion, and I will construct the universe.' In fact, leaving the more shadowy past alone, we may say that it is since Descartes watched the fountains in the garden, and saw the likeness between their machinery of pumps and pipes and reservoirs to the organs of the circulation of the blood, and since Vaucanson's marvellous automata lent plausibility to the idea of a 'living automaton,' it is since then that men's minds have been perpetually swayed by one or other of the two conflicting tendencies, either to seek an explanation of the phenomena of living things in physical and mechanical considerations, or to attribute them to unknown and mysterious causes, alien to physics and peculiarly concomitant with life. And some men's temperaments, training, and even avocations, render them more prone to the one side of this unending controversy, as the minds of other men are naturally more open to the other. As Kuhne said a few years ago at Cambridge, the physiologists have been found for several generations leaning on the whole to the mechanical or physico-chemical hypothesis, while the zoologists have been very generally on the side of the Vitalists.

The very fact that the physiologists were trained in the school of physics, and the fact that the zoologists and botanists relied for so many years upon the vague undefined force of 'heredity' as sufficiently accounting for the development of the organism, an intrinsic force whose results could be studied but whose nature seemed remote from possible analysis or explanation, these facts alone go far to illustrate and to justify what Kühne said.

Claude Bernard held that mechanical, physical, and chemical forces summed up all with which the physiologist has to deal. Verworn defined physiology as 'the chemistry of the proteids'; and I think that another physiologist (but I forget who) has declared that the mystery of life lay hidden in 'the chemistry of the enzymes.' But of late, as Dr. Haldane showed in his address a couple of years ago to the Physiological Section, it is among the physiologists themselves, together with the embryologists, that we find the strongest indications of a desire to pass beyond the horizon of Descartes, and to avow that physical and chemical methods, the methods of Helmholtz, Ludwig, and Claude Bernard, fall short of solving the secrets of physiology. On the other hand, in zoology, resort to the method of experiment, the discovery, for instance, of the wonderful effects of chemical or even mechanical stimulation in starting the development of the egg, and again the ceaseless search into the minute structure, or so-called mechanism, of the cell, these, I think, have rather tended to sway a certain number of zoologists in the direction of the mechanical hypothesis.

But on the whole, I think it is very manifest that there is abroad on all sides a greater spirit of hesitation and caution than of old, and that the lessons of the philosopher have had their influence on our minds. We realise that the

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[1] 'Cum formarum naturalium et corporalium esse non consistat nisi in unione ad materiam; ejusdem agentis esse videtur eas producere, cujus est materiam transmutare. Secundo, quia cum hujusmodi formae non excedant virtutem et ordinem et facultatem principiorum agentium in natura, nulla videtur necessitas eorum originem in principia reducere altiora.'—Aquinas, *De Pot.* Q. iii., a. 11; Cf. Harper, *Metaphysics of the School*, iii. 1, p. 152.

problem of development is far harder than we had begun to let ourselves suppose: that the problems of organogeny and phylogeny (as well as those of physiology) are not comparatively simple and well-nigh solved, but are of the most formidable complexity. And we would, most of us, confess, with the learned author of 'The Cell in Development and Inheritance,' 'that we are utterly ignorant of the manner in which the substance of the germ-cell can so respond to the influence of the environment as to call forth an adaptive variation; and again, that the gulf between the lowest forms of life and the inorganic world is as wide as, if not wider than, it seemed a couple of generations ago.'[4]

While we keep an open mind on this question of Vitalism, or while we lean as so many of us now do, or even cling with a great yearning, to the belief that something other than the physical forces animates and sustains the dust of which we are made, it is rather the business of the philosopher than of the biologist, or of the biologist only when he has served his humble and severe apprenticeship to philosophy, to deal with the ultimate problem. It is the plain bounden duty of the biologist to pursue his course, unprejudiced by vitalistic hypotheses, along the road of observation and experiment, according to the accepted discipline of the natural and physical sciences; indeed, I might perhaps better say the physical sciences alone, for it is already a breach of their discipline to invoke, until we feel we absolutely must, that shadowy force of 'heredity' to which, as I have already said, biologists have been accustomed to ascribe so much. In other words, it is an elementary scientific duty, it is a rule that Kant himself laid down,[5] that we should explain, just as far as we possibly can, all that is capable of such explanation, in the light of the properties of matter and of the forms of energy with which we are already acquainted.

It is of the essence of physiological science to investigate the manifestations of energy in the body, and to refer them, for instance, to the domains of heat, electricity, or chemical activity. By this means a vast number of phenomena, of chemical and other actions of the body, have been relegated to the domain of physical science and withdrawn from the mystery that still attends on life: and by this means, continued for generations, the physiologists, or certain of them, now tell us that we begin again to descry the limitations of physical inquiry, and the region where a very different hypothesis insists on thrusting itself in. But the morphologist has not gone nearly so far as the physiologist in the use of physical methods. He sees so great a gulf between the crystal and the cell, that the very fact of the physicist and the mathematician being able to explain the form of the one, by simple laws of spatial arrangement where molecule fits into molecule, seems to deter, rather than to attract, the biologist from attempting to explain organic forms by mathematical or physical law. Just as the embryologist used to explain everything by heredity, so the morphologist is still inclined to say—'the thing is alive, its form is an attribute of itself, and the physical forces do not apply.' If he does not go so far as this, he is still apt to take it for granted that the physical forces can only to a small and even insignificant extent blend with the intrinsic organic forces in producing the resultant form. Herein lies our question in a nutshell. Has the morphologist yet sufficiently studied the forms, external and internal, of organisms, in the light of the properties of matter, of the energies that are associated with it, and of the forces by which the actions of these energies may be interpreted and described? Has the biologist, in short, fully recognised that there is a borderland not only between physiology and physics, but between morphology and physics, and that the physicist may, and must, be his guide and teacher in many matters regarding organic form?

Now this is by no means a new subject, for such men as Berthold and Errera, Rhumbler and Dreyer, Bütschli and Verworn, Driesch and Roux, have already dealt or deal with it. But on the whole it seems to me that the subject has attracted too little attention, and that it is well worth our while to think of it to-day.

The first point, then, that I wish to make in this connection is, that the Form of any portion of matter, whether it be living or dead, its form and the changes

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[4] Wilson, *op. cit.*, 1906, p. 434.

[5] In his *Critique of Teleological Judgment.*

of form that are apparent in its movements and in its growth, may in all cases alike be described as due to the action of Force. In short, the form of an object is a 'diagram of forces'—in this sense at least, that from it we can judge of or deduce the forces that are acting or have acted upon it; in this strict and particular sense, it is a diagram: in the case of a solid, of the forces that *have* been impressed upon it when its conformation was produced, together with those that enable it to retain its conformation; in the case of a liquid (or of a gas), of the forces that are for the moment acting on it to restrain or balance its own inherent mobility. In an organism, great or small, it is not merely the nature of the *motions* of the living substance that we must interpret in terms of Force (according to kinetics), but also the *conformation* of the organism itself, whose permanence or equilibrium is explained by the interaction or balance of forces, as described in Statics.

If we look at the living cell of an Amœba or a Spirogyra, we see a something which exhibits certain active movements, and a certain fluctuating, or more or less lasting, form; and its form at a given moment, just like its motions, is to be investigated by the help of physical methods, and explained by the invocation of the mathematical conception of force.

Now the state, including the shape or form, of a portion of matter is the resultant of a number of forces, which represent or symbolise the manifestations of various kinds of Energy; and it is obvious, accordingly, that a great part of physical science must be understood or taken for granted as the necessary preliminary to the discussion on which we are engaged.

I am not going to attempt to deal with, or even to enumerate, all the physical forces or the properties of matter with which the pursuit of this subject would oblige us to deal—with gravity, pressure, cohesion, friction, viscosity, elasticity, diffusion, and all the rest of the physical factors that have a bearing on our problem. I propose only to take one or two illustrations from the subject of *surface-tension*, which subject has already so largely engaged the attention of the physiologists. Nor will I even attempt to sketch the general nature of this phenomenon, but will only state (as I fear for my purpose I must) a few of its physical manifestations or laws. Of these the most essential facts for us are as follows: Surface-tension is manifested only in fluid or semi-fluid bodies, and only at the surface of these: though we may have to interpret surface in a liberal sense in cases where the interior of the mass is other than homogeneous. Secondly, a fluid may, according to the nature of the substance with which it is in contact, or (more strictly speaking) according to the distribution of energy in the system to which it belongs, tend either to spread itself out in a film, or, conversely, to contract into a drop, striving in the latter case to reduce its surface to a minimal area. Thirdly, when three substances are in contact (and subject to surface-tension), as when water surrounds a drop of protoplasm in contact with a solid, then at any and every point of contact, certain definite angles of equilibrium are set up and maintained between the three bodies, which angles are proportionate to the magnitudes of the surface-tensions existing between the three. Fourthly, a fluid film can only remain in equilibrium when its curvature is everywhere constant. Fifthly, the only surfaces of revolution which meet this condition are six in number, of which the plane, the sphere, the cylinder, and the so-called unduloid and catenoid are the most important. Sixthly, the cylinder cannot remain in free equilibrium if prolonged beyond a length equal to its own circumference, but, passing through the unduloid, tends to break up into spheres: though this limitation may be counteracted or relaxed, for instance, by viscosity. Finally, we have the curious fact that, in a complex system of films, such as a homogeneous froth of bubbles, three partition-walls and no more always meet at a crest, at equal angles, as, for instance, in the very simple case of a layer of uniform hexagonal cells; and (in a solid system) the crests, which may be straight or curved, always meet, also at equal angles, four by four, in a common point. From these physical facts, or laws, the morphologist, as well as the physiologist, may draw important consequences.

It was Hofmeister who first showed, more than forty years ago, that when any drop of protoplasm, either over all its surface or at some free end (as at the tip of the pseudopodium of an Amœba), is seen to 'round itself off,' that is not the effect of physiological or vital contractility, but is a simple consequence of

surface-tension—of the law of the minimal surface; and in the physiological side, Engelmann, Bütschli, and others have gone far in their development of the idea.

It was Plateau, I think, who first showed that the myriad sticky drops or beads upon the weft of a spider's web, their form, their size, their distance apart, and the presence of the tiny intermediate drops between, were in every detail explicable as the result of surface-tension, through the law of minimal surface and through the corollary to it which defines the limits of stability of the cylinder; and, accordingly, that with their production, the will or effort or intelligence of the spider had nothing to do. The beaded form of a long, thin pseudopodium, for instance of a Heliozoan, is an identical phenomenon.

It was Errera who first conceived the idea that not only the naked surface of the cell but the contiguous surfaces of two naked cells, or the delicate incipient cell-membrane or cell-wall between, might be regarded as a weightless film, whose position and form were assumed in obedience to surface-tension. And it was he who first showed that the symmetrical forms of the unicellular and simple multicellular organisms, up to the point where the development of a skeleton complicates the case, were one and all identical with the plane, sphere, cylinder, unduloid and catenoid, or with combinations of these.

It was Berthold and Errera who, almost simultaneously, showed (the former in far the greater detail) that in a plant each new cell-partition follows the law of minimal surface, and tends (according to another law which I have not particularised) to set itself at right angles to the preceding solidified wall: so giving a simple and adequate physical explanation of what Sachs had stated as an empirical morphological rule. And Berthold further showed how, when the cell-partition was curved, its precise curvature as well as its position was in accordance with physical law.

There are a vast number of other things that we can satisfactorily explain on the same principle and by the same laws. The beautiful catenary curve of the edge of the pseudopodium, as it creeps up its axial rod in a Heliozoan or a Radiolarian, the hexagonal mesh of bubbles, or vacuoles, on the surface of the same creatures, the form of the little groove that runs round the waist of a Peridinian, even (as I believe) the existence, form, and undulatory movements of the undulatory membrane of a Trypansome, or of that around the tail of the spermatozoon of a newt—every one of these, I declare, is a case where the resultant form can be well explained by, and cannot possibly be understood without, the phenomena of surface-tension: indeed, in many of the simpler cases the facts are so well explained by surface-tension that it is difficult to find place for a conflicting, much less an overriding, force.

I believe, for my own part, that even the beautiful and varied forms of the Foraminifera may be ascribed to the same cause; but here the problem is just a little more complex, by reason of the successive consolidations of the shell. Suppose the first cell or chamber to be formed, assuming its globular shape in obedience to our law, and then to secrete its calcareous envelope. The new growing bud of protoplasm, accumulating outside the shell, will, in strict accordance with the surface-tensions concerned, either fail to 'wet' or to adhere to the first-formed shell, and will so detach itself as a unicellular individual (*Orbulina*); or else it will flow over a less or greater part of the original shell, until its free surface meets it at the required angle of equilibrium. Then, according to this angle, the second chamber may happen to be all but detached (*Globigerina*), or, with all intermediate degrees, may very nearly wholly enwrap the first. Take any specific angle of contact, and presume the same conditions to be maintained, and therefore the same angle to be repeated, as each successive chamber follows on the one before; and you will thereby build up regular forms, spiral or alternate, that correspond with marvellous accuracy to the actual forms of the Foraminifera. And this case is all the more interesting because the allied and successive forms so obtained differ only in degree, in the magnitude of a single physical or mathematical factor; in other words, we get not only individual phenomena, but lines of apparent *orthogenesis*, that seem explicable by physical laws, and attributable to the continuity between successive states in the continuous or gradual variation of a physical condition. The resemblance between allied and related forms, as Hartmann demonstrated and Giard admitted years

ago, is not always, however often, to be explained by common descent and parentage.[6]

In the segmenting egg we have the simpler phenomenon of a 'laminar system,' uncomplicated by the presence of a solid frame-work; and here, in the earliest stages of segmentation, it is easy to see the correspondence of the planes of division with what the laws of surface-tension demand. For instance, it is not the case (though the elementary books often represent it so) that when the totally segmenting egg has divided into four segments, the four partition walls ever remain in contact at a single point; the arrangement would be unstable, and the position untenable. But the laws of surface-tension are at once seen to be obeyed, when we recognise the little *cross-furrow* that separates the blastomeres, two and two, leaving in each case three only to meet at a point in our diagram, which point is in reality a section of a ridge or crest.

Very few have tried, and one or two (I know) have tried and not succeeded, to trace the action and the effects of surface-tension in the case of a highly complicated, multi-segmented egg. But it is not surprising if the difficulties which such a case presents appear to be formidable. Even the conformation of the interior of a soap-froth, though absolutely conditioned by surface tension, presents great difficulties, and it was only in the last years of Lord Kelvin's life that he showed all previous workers to have been in error regarding the form of the interior cells.

But what, for us, does all this amount to? It at least suggests the possibility of so far supporting the observed facts of organic form on mathematical principles, as to bring morphology within or very near to Kant's demand that a true natural science should be justified by its relation to mathematics.[7] But if we were to carry these principles further and to succeed in proving them applicable in detail, even to the showing that the manifold segmentation of the egg was but an exquisite froth, would it wholly revolutionise our biological ideas? It would greatly modify some of them, and some of the most cherished ideas of the majority of embryologists; but I think that the way is already paved for some such modification. When Loeb and others have shown us that half, or even a small portion of an egg, or a single one of its many blastomeres, can give rise to an entire embryo, and that in some cases *any* part of the ovum can originate *any* part of the organism, surely our eyes are turned to the *energies* inherent in the matter of the egg (not to speak of a presiding entelechy), and away from its original formal operations of division. Sedgwick has told us for many years that we look too much to the individuality of the individual cell, and that the organism, at least in the embryonic body, is a continuous syncytium. Hofmeister and Sachs have repeatedly told us that in the plant, the growth of the mass, the growth of the organ, is the primary fact; and De Bary has summed up the matter in his aphorism, *Die Pflanze bildet Zellen, nicht die Zelle bildet Pflanzen.* And in many other ways, as many of you are well aware, the extreme position of the cell-theory, that the cells are the ultimate individuals, and that the organism is but a colony of quasi-independent cells, has of late years been called in question.

There are no problems connected with Morphology that appeal so closely to my mind, or to my temperament, as those that are related to mechanical considerations, to mathematical laws, or to physical and chemical processes.

I love to think of the logarithmic spiral that is engraven over the grave of that great anatomist, John Goodsir (as it was over that of the greatest of the Bernouillis), so graven because it interprets the form of every molluscan shell, of tusk and horn and claw, and many another organic form besides. I like to dwell upon those lines of mechanical stress and strain in a bone that give it its strength where strength is required, that Hermann Meyer and J. Wolff described, and on which Roux has bestowed some of his most thoughtful work;

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[6] Cf. Giard, 'Discours inaugurale,' *Bull. Scientif.* (3), 1, 1888.

[7] 'Ich behaupte aber dass in jeder besonderen Naturlehre so viel *eigentliche* Wissenschaft angetroffen werden könne, als darin Mathematik anzutreffen ist.'—Kant, in Preface to *Metaphys. Anfangsgründe der Naturwissenschaft* (*Werke*, ed. Hartenstein, vol. iv., p. 360).

or on the 'stream-lines' in the bodily form of fish or bird, from which the naval architect and the aviator have learned so much. I admire that old paper of Peter Harting's in which he paved the way for investigation of the origin of spicules, and of all the questions of crystallisation or pseudo-crystallisation in presence of colloids, on which subject Lehmann has written his recent and beautiful book I sympathise with the efforts of Henking, Rhumbler, Hartog, Gallardo, Leduc, and others to explain on physical lines the phenomena of nuclear division. And, as I have said to-day, I believe that the forces of surface-tension, elasticity, and pressure are adequate to account for a great multitude of the simpler phenomena, and the permutations and combinations thereof, that are illustrated in organic Form.

I should gladly and easily have spent all my time this morning in dealing with these questions alone. But I was loth to do so, lest I should seem to overrate their importance, and to appear to you as an advocate of a purely mechanical biology.

I believe all these phenomena to have been unduly neglected, and to call for more attention than they have received. But I know well that though we push such explanations to the uttermost, and learn much in the so doing, they will not touch the heart of the great problems that lie deeper than the physical plane. Over the ultimate problems and causes of vitality, over what is implied in the organisation of the living organism, we shall be left wondering still.

To a man of letters and the world like Addison, it came as a sort of revelation that Light and Colour were not objective things but subjective, and that back of them lay only motion or vibration, some simple activity. And when he wrote his essay on these startling discoveries, he found for it, from Ovid, a motto well worth bearing in mind, *causa latet, vis est notissima.* We may with advantage recollect it, when we seek and find the Force that produces a direct Effect, but stand in utter perplexity before the manifold and transcendent meanings of that great word 'cause.'

The similarity between organic forms and those that physical agencies are competent to produce still leads some men, such as Stéphane Leduc, to doubt or to deny that there is any gulf between, and to hold that spontaneous generation or the artificial creation of the living is but a footstep away. Others, like Delage and many more, see in the contents of the cell only a complicated chemistry, and in variation only a change in the nature and arrangement of the chemical constituents; they either cling to a belief in 'heredity,' or (like Delage himself) replace it more or less completely by the effects of functional use and by chemical stimulation from without and from within. Yet others, like Felix Auerbach, still holding to a physical or quasi-physical theory of life, believe that in the living body the dissipation of energy is controlled by a guiding principle, as though by Clerk Maxwell's demons; that for the living the Law of Entropy is thereby reversed; and that Life itself is that which has been evolved to counteract and battle with the dissipation of energy. Berthold, who first demonstrated the obedience to physical laws in the fundamental phenomena of the dividing cell or segmenting egg, recognises, almost in the words of John Hunter, a quality in the living protoplasm, *sui generis*, whereby its maintenance, increase, and reproduction are achieved. Driesch, who began as a 'mechanist,' now, as we have seen, harks back straight to Aristotle, to a twin or triple doctrine of the soul. And Bergson, rising into heights of metaphysics where the biologist, *quâ* biologist, cannot climb, tells us (like Duran) that life transcends teleology, that the conceptions of mechanism and finality fail to satisfy, and that only 'in the absolute do we live and move and have our being.'

We end but a little way from where we began.

With all the growth of knowledge, with all the help of all the sciences impinging on our own, it is yet manifest, I think, that the biologists of to-day are in no self-satisfied and exultant mood. The reasons and the reasoning that contented a past generation call for re-inquiry, and out of the old solutions new questions emerge; and the ultimate problems are as inscrutable as of old. That which, above all things, we would explain baffles explanation; and that the living organism is a living organism tends to reassert itself as the biologist's fundamental conception and fact. Nor will even this concept serve us and suffice us when we approach the problems of consciousness and intelligence and the

mystery of the reasoning soul; for these things are not for the biologist at all, but constitute the Psychologist's scientific domain.

In Wonderment, says Aristotle, does philosophy begin,[8] and more than once he rings the changes on the theme. Now, as in the beginning, wonderment and admiration are the portion of the biologist, as of all those who contemplate the heavens and the earth, the sea, and all that in them is.

And if Wonderment springs, as again Aristotle tells us, from ignorance of the causes of things, it does not cease when we have traced and discovered the proximate causes, the physical causes, the Efficient Causes of our phenomena. For beyond and remote from physical causation lies the End, the Final Cause of the philosopher, the reason Why, in the which are hidden the problems of organic harmony and autonomy and the mysteries of apparent purpose, adaptation, fitness, and design. Here, in the region of teleology, the plain rationalism that guided us through the physical facts and causes begins to disappoint us, and Intuition, which is of close kin to Faith, begins to make herself heard.

And so it is that, as in Wonderment does all philosophy begin, so in Amazement does Plato tell us that all our philosophy comes to an end.[9] Ever and anon, in presence of the *magnalia naturæ*, we feel inclined to say with the poet: —

> οὐ γάρ τι νῦν γε κἀχθὲς, ἀλλ' ἀεί ποτε
> ζῇ ταῦτα, κοὐδεὶς οἶδεν ἐξ ὅτου 'φάνη.

'These things are not of to-day nor yesterday, but evermore, and no man knoweth whence they came.'

I will not quote the noblest words of all that come into my mind; but only the lesser language of another of the greatest of the Greeks: 'The ways of His thoughts are as paths in a wood thick with leaves, and one seeth through them but a little way.'

The following Papers were then read :—

1. *The Vernal-Plumage Changes in the Adolescent Blackbird* (Turdus merula) *and their Correlation with Sexual Maturity.* *By* C. J. PATTEN, *M.A., M.D., Sc.D.*

The question regarding the age at which wild birds first begin to breed seems to have received but scant attention. Evidence has been put forward on the ground that because a bird has arrived at an age when it assumes a permanent pattern of plumage (that is to say, a plumage repeated during subsequent years), the first appearance of this plumage signifies the hall-mark of sexual maturity. A gannet takes five years before reaching its permanent plumage-garb, this also applies to some of the gulls; other birds take three, others two, while some of the shorter-lived species probably appear in permanent dress when twelve months old. But the question arises—are all such birds sexually mature when they first don their permanent garb? From observations made on *Calidris arenaria* (sanderling), I have already shown that in this species there is assumed an apparent nuptial plumage which precedes sexual maturity. At the same time this *pre-nuptial plumage*[1] (as I have called it) in this species so closely resembles the plumage of the sexually mature bird that only a trained and practised eye could discern the difference. And whether that difference exists as a result in other species is a matter for future investigation. But, as before mentioned,[2] I have reason to believe that other species of shore-birds besides the sanderling take more than one year to reach maturity, and that prior to this period they may assume a summer-garb to all intents and purposes identical with the dress worn

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[8] *Met.*, I., 2, 982b, 12, &c.

[9] Cf. Coleridge, *Biogr. Lit.*

[1] 'The Pre-nuptial Plumage in *Calidris arenaria*,' *Brit. Assoc. Report*, Winnipeg, 1909, p. 505.

[2] 'Semination in *Calidris arenaria*,' *Brit. Assoc. Report*, Sheffield, 1910, pp. 637, 638.

at that time of the year when sexually mature. From this and from what I have to say presently in the case of the blackbird's vernal-moult at the adolescent stage of growth, it is quite evident that it is an unsafe procedure to determine the maturity of a bird by its plumage-markings, and here we may in many cases include colour-changes in the iris and beak and other secondary sexual characters when present.[3] The testes at the same time demand anatomical investigation with and without the aid of the microscope. As I have received several blackbirds during the spring of this year, whilst securing the skins for research in other directions, I thought it advisable to take the opportunity of examining the testes with a view of throwing light on the question at issue Avoiding details in regard to plumage-changes, it may be here noted that, as a rule, there is no difficulty in distinguishing the male blackbird in its first spring-plumage (*i.e.*, when about twelve months old) from the adult of the corresponding time of year. For the former is usually very dark brownish-black, with a blackish beak; the latter jet-black, with a deep-yellow beak. But (as in a specimen now before me) the yellow coloration of the beak may appear during the first year coupled with plumage so nearly approaching jet-black that on general inspection the bird in such dress might pass as being fully matured. The yellow beak is usually looked upon as the last sign of maturity; 'even after assuming the adult plumage, young males of the year have blackish beaks until their second year.'[4] It may be seen from this passage just quoted that here the term 'adult plumage' has been adopted for what seems to me to express the adolescent plumage, which, according to the varying degree of blackness, may approach more or less, or even be practically indistinguishable from, the true adult garb. Again, I have examined an adolescent blackbird obtained in March possessing a yellow beak, but whose blackish-brown under plumage showed rufous edgings, often present in the plumage of the first winter. Examination of the testes of the above-mentioned birds at once throws light on the question regarding the adult character of the beak. The development of yellow pigment was a matter of precocity, which development outstripped in time the assumption of the true adult plumage, which would not follow till the next year. For the testes showed distinct signs of immaturity. Examined microscopically their greatest length did not exceed 5 mm., their greatest breadth 2·6 mm. On the contrary, in the case of mature birds these organs averaged during the first week of March 1·8 cm. long and 1 cm. broad. Histological examination revealed a striking difference. In the adolescent birds the tubules were at least fifty times smaller than were those of the adult. Moreover, in the former there was no sign of spermatogenesis taking place in the tubules, while in the latter countless swarms of ripe sperm-cells occupied the entire microscopic field in one great tubule; one-sixth objective being used in the examination in each case. Hence, in regard to these adolescent birds (examined all about the same time, viz., first two weeks in March), I have no hesitation in expressing an opinion that they would not have reached maturity until the next spring, despite the fact that in one specimen the plumage was nearly fully black and the beak yellow, and in another specimen with blackish-brown plumage, the beak had turned yellow, bearing in mind that not until the real adult plumage is assumed in the second autumn does the beak usually begin to gain its characteristic shade.

2. *A Case of a remarkable Egg of* Falco tinnunculus *laid under remarkable circumstances.* *By* C. J. PATTEN, *M.A., M.D., Sc.D.*

On Sunday, June 11 last, my tame kestrel, which I have had for eight years, appeared to be in a remarkably lively mood. When let out of her wire enclosure she indulged in her usual trick of pouncing on my shoe and biting at

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[3] An interesting experiment illustrating the fact that the close correlation between the assumption of nuptial plumage and sexual maturity may be broken down, is seen when a few of the first brown feathers of an immature blackbird (male) are pulled out, which are replaced by black, *i.e.*, *nuptialoid* feathers.

[4] *Vide* Saunders, *Man. Brit. Birds*, second edit., 1899, p. 14.

the leather repeatedly. When I shook her off she followed me across the yard, and on presenting my gloved hand she dashed at it, at the same time dropping her wings like a curtain, as though she were shielding her favourite mouse. Many other tricks which I have frequently found her indulging in were particularly well performed that morning. I was therefore exceedingly pleased that after my absence from home for the greater part of the preceding week I returned to find her so well and lively. However, in the afternoon a remarkable change came over her. She retired to a corner, and, assuming an almost horizontal position, so that her head, back, and tail were almost parallel with the ground, she became so apathetic that I suspected poisoning from some of the food (a young rat caught in a trap) of which she had lately partaken. Unable to rouse her, I carried her into my study, where she again crept into a corner and behaved similarly. She remained in this condition until 6.30 P.M., at which time I left her alone. On my return at 10.30 P.M. she still appeared to be in the same condition. I tried to rouse her by pretending to attack her with my hand and by splashing her with cold water, but it was of no avail. I then left her in the corner while I wrote some letters. She now began to utter a few faint squeaks at intervals. At 11.45 P.M. she gave a rather painful cry, and on going over to see what was the matter I found she had laid an egg. Almost immediately she began to get lively, and so I had to exercise care lest she might perhaps break the egg. Fortunately I succeeded in getting possession of the egg safely. Remarkable as this case of ovulation may be, the egg itself is none the less remarkable. Although the usual brownish-red egg (so profusely pigmented that no trace of white is visible) may sometimes be represented by one richly mottled on a yellowish-white or pinkish ground-colour, I may say I have never before seen a kestrel's egg such as the one my bird laid. This egg is milky-white in colour, almost unspotted except at its larger end. This part is spotted and blotched with rich purplish-brown intermixed with light greyish-purple, the whole pigmentation forming a broken zonular band. The egg might be compared to an enlarged model of a greenfinch's egg in which the ground-colour has lost its faint greenish hue. The texture of the shell is fine and thin, but sufficiently strong to allow of the contents being extruded by means of the blow-pipe. The egg is less rounded at the smaller end than usual, and resembles in shape an ordinary domestic fowl's egg. In size it is perfectly normal, viz., length, 3·9 cm.; breadth, 3 cm.; the average measurements given for the kestrel's egg by Saunders being, length, 4 cm.; breadth, 3·1 cm. That is to say, my kestrel's egg is 1 mm. less than the normal in length and in breadth. It seems impossible to offer an explanation for this strange case of ovulation. But I may perhaps be allowed to refer to one point in connection with the bird's diet just before it laid the egg. During my absence from home, which lasted four days, the bird was supplied with sufficient food for that time, but it was all given on the first day. When I returned the greater part was untouched, the reason being that the warm weather had affected the food sufficiently to render it adverse to the bird's palate. Hence the hawk fasted for three days. On my return I gave her a plentiful supply of fresh ox spleen and liver, with which she gorged herself, and this highly nutritious hearty meal, coming after a fast and in a warm change of weather, may have toned her to such a physiological state that her ovaries became sufficiently active to induce ovulation. Such an explanation is vague and theoretical, and I give it only for what it is worth. [The coloured photograph exhibited was taken before the egg was blown, in order to secure the best results before slight fading of the pigment subsequent to blowing ensued.]

3. *Fairy Flies. By* F. Enoch.

FRIDAY, SEPTEMBER 1.

The following Papers and Reports were read :—

1. *On a new Gymnoblastic Hydroid* (Ichthyocodium sarcotretis), *epizoic on a new Parasitic Copepod* (Sarcotretes scopeli) *infesting* Scopelus glacialis (Rhos.). *By* HECTOR F. E. JUNGERSEN.

(i) The *Hydroid* coats more or less of the external part of a Parasitic Copepod deeply sunk into the body of *Scopelus glacialis*. It consists of (1) Polypes devoid of tentacles and growing from a network of delicate tubes enclosed in a basal membrane without perisarc; (2) Medusa-buds arising from the base of the Polypes. The largest buds possess a bell with two marginal tentacles and four simple radial canals; the manubrium is distinct; when fully developed they are set free as Medusæ (Anthomedusæ). This new Hydroid is related to *Hydrichthys mirus* (Fewkes), epizoic on the fish *Seriola zonata*, and has to be adopted into the family of *Corynidæ* as defined by *Stechow* (1909).

(ii) The *Parasitic Copepod Sarcotretes scopeli* represents a new genus and species of the family *Lernæidæ*, allied to genera like *Peroderma Lernæenicus*, Lernœa, Pamella. The adult female has an elongated body; the middle part of the long genital segment is constricted into a narrow, firmly chitinised stalk; only the distal, claviform part behind the stalk protrudes outside the host. Cephalothorax with the dorsal shield fully preserved; two large clumsy outgrowths arise below the margins of the shield; no other outgrowths are present. The antennules are linear, the antennæ cheliform, the sipho large; one pair of maxillipeds; three pairs of abdominal feet, the two anterior biramous, the posterior uniramous; three free abdominal segments with well developed tergal and sternal parts. It is found in the eastern part of the Atlantic, inserted into the body of *Scopelus glacialis*, the body-wall of which it pierces, penetrating to the alimentary tract.

On the same species of fish has been found a series of its *Metamorphosis-stages*: (1) A *Cyclops-stage*, resembling that of *Lernæa branchialis*, capable of moving along on the host and attaching itself by its strong cheliform antennæ; (2) Four *Pupa-stages*, passively fixed to their host by means of a hardened secretion from the rostrum.

Inside the last Pupa the *copulatory form* has been observed. The copulatory form probably lives for a while in a free state. After impregnation the female takes up the parasitic life anew, but in a more intense form : it pierces the skin of a *Scopelus glacialis*, and, gradually growing, it penetrates through the muscles and reaches by and by the intestines of the host.

The triple association between the Fish, the Copepod, and the Hydroid seems to be a regular one : of fourteen adult *Sarcotretes* seven carry the *Ichthyocodium*, and the loss of tentacles in the Polypes of the latter seems to show that the Hydroid in some way or other depends on the fish for getting its food.

2. *On the Species of the Genus* Balanus *collected in the Malay Archipelago during the Cruise of the Dutch Man-of-war 'Siboga.' By* DR. P. P. C. HOEK.

The Archipelago is very rich in forms of this genus. Darwin, whose most excellent monograph remains the standard work for the group Cirripedia (and, I might say, for the difficult genus *Balanus* especially), knew and described (1854) forty-five of its species, thirty-nine of which are living species, six found fossil only. Sixteen of the living species, according to Darwin, live in the Malay Archipelago and surrounding seas (coast of Bengal, Ceylon, Australia), and this number has but slightly increased since the appearance of his book; taking the region in somewhat extended form, the whole number of species known to occur there at present can be estimated as twenty-five at most.

In the collections made by Professor Weber during the cruise of the 'Siboga,' the genus *Balanus* was found to be represented by twenty-seven

species, and (I am almost sorry to say) nineteen of these must be considered as new to science. Most of these were dredged at some depth, the already known and described species of the collection being to a large extent (as is easily understood) those collected during shore exploration. Few species, however, were brought up from great depths; most of them inhabit water the depth of which does not exceed 75 to 90 m. At *very* considerable depth no species of *Balanus* was collected, those brought up from the deepest water being:—

B. alatus, n.sp.	from 564 m.	*B. pentacrini*, n.sp.	from 304 m.
B. albus, n.sp	,, 289 m.	*B. tenuis* (Hoek)	,, 275 m.
B. echinicola, n.sp.	,, 216 m.	*B. velutinus*, n.sp.	,, 390 m.

Of the first three of these species, however, specimens were also collected at a depth of less than 100 m.

In the rich and interesting collections brought home by the 'Challenger,' the Cirripedia of which I had the pleasure to work up, the genus *Balanus* was found represented by nine species, two of which belonged to a special section of deep-sea forms. Since the publication of my report (1883) two species more of this section were described by Pilsbry. The new 'Siboga' species, *B. velutinus*, belongs also to this section, so that we know five species at present, the distribution of which is a very wide one, as may be judged from the following:—

B. coralliformis (Hoek), 270 m., between Kerguelen and Heard Islands;
B. hirsutus (Hoek), 930 m., Faroe Channel;
B. hoekianus (Pilsbry), 77 m., Bering Sea;
B. callistoderma (Pilsbry), 140 m., Suruga Gulf, Japan; and
B. velutinus, n.sp., 204-390 m, Malay Archipelago.

The species of this section are characterised by the compartments wanting radii and (so far I have investigated the species myself) by the structure of the labrum, which has no notch and no teeth or a row of numerous little nobs instead of such teeth. I think, however, we do better not to consider these forms as more primitive than those with radii and teeth on both sides of a notched labrum, but rather as species somewhat degenerated perhaps in consequence of isolation.

Of the remaining new species three belong to Darwin's section B, species with boat-shaped basis attached to Gorgoniæ, Milleporæ, &c., and one to section E, which species is nearly related to Darwin's *B. declivis*. The remaining, fourteen in all, forming a large proportion of the new species, belong to Darwin's section F, the species of which have the parietes and radii not permeated by pores, and the basis sometimes permeated and sometimes not permeated by pores and sometimes extremely thin. These species caused me great trouble. A very detailed study of the compartments, of the opercular valves, and of the animal's body was necessary to determine them, the difficulty being greatly enlarged by the circumstance that the dredged species as a rule are represented by single or very few specimens only. For the description of the new species, most of which are interesting in several respects, the printed report is to be consulted, which will be put in the press at an early date.

The species of *Balanus* observed in the Malay Archipelago, with few exceptions only—*B. amphitrite*, *B. amaryllis*, *B. tintinnabulum*, &c.—seem to have a limited geographical distribution; at least as far as we know at present. For we are not to forget that the marine fauna of some parts of the world's surface has not up till now been so carefully investigated as is the case with the Malay Archipelago. Moreover, a very detailed description of a species of *Balanus* is necessary to recognise it with certainty. I think it is a most interesting genus but notwithstanding the most excellent way in which Darwin started its study, it has, perhaps in consequence of the difficulties attached to it, been somewhat neglected hitherto. Perhaps my investigation of the 'Siboga' species will encourage others to continue the study of these animals. They will not be disappointed

3. *Five Years' Danish Investigations on the Biology of the Eel.*
By Dr. J. Schmidt.

About twenty years ago our knowledge of the natural history of the eels was greatly advanced by the investigations of the Italian zoologist Grassi and his pupil Calandruccio. Before that time nothing or almost nothing, was known, and then all at once an answer was given to several fundamental questions: for example, that the larval stages of the eels are the long-known Leptocephali; by a process of metamorphosis these become young eels. Further, it was shown that *Leptocephalus brevirostris* was the larva of the freshwater eel and *Leptocephalus morrisii* the larva of the conger. Both of these species are very common in our northern seas and in the Mediterranean, where the Italians carried out their investigations. As is well known, the Italian observers obtained their material from the Straits of Messina, and in two different ways: on the one hand, from the stomachs of the Sunfish, which, as it feeds on Leptocephali, is an excellent fishing apparatus for obtaining these animals. Further, the currents in the Straits of Messina, which have been known to be peculiar from the most ancient times, were also of special use to them, as many marine animals, even deep-water forms, are washed up on the shore at Faro, in the northern part of the Straits, where they can be collected on the beach.

A remarkable thing was that the Leptocephali were only known in quantities from the Straits of Messina, not from other parts of the Mediterranean. And Grassi and Calandruccio thought that this was due in the main to the remarkable whirlpools of the straits of Messina, which bring up the larvæ from the deep water or bottom of the sea, to which they were supposed to belong.

The discoveries of Grassi and Calandruccio naturally created quite a sensation everywhere. The puzzle, the reproduction of the eels, over which so many had speculated for centuries, now seemed to have received its solution; and yet there was some considerable doubt about the matter, especially in Northern Europe, where the two species of eels mentioned are very common and important. So far as the transformation of the Leptocephali to young eels is concerned, this doubt has not been justified; in this respect our investigations in the Mediterranean have fully confirmed the great discoveries of the Italian observers. But, on the other hand, it has proved that the observations made in the Straits of Messina could not be considered as holding good for the conditions in North and West Europe, and that the solution given of the reproduction of the conger and freshwater eel was by no means the final one.

In the years following the appearance of the work of Grassi and his pupil, various experts on the biology of fishes, both in this country and on the Continent, endeavoured to explain why it was that the larvæ of the conger and eel were never, or practically never, found in the waters of Northern Europe. The one who has dealt with this subject in most detail is, so far as I know, Cunningham, who in a discussion of Grassi's work in 1895 made the following statement: 'There can be little doubt that the larvæ of the conger and of the eel exist around our coasts in great abundance under stones and buried in sand or gravel, and that we do not catch them because we do not know the right way to go about it.' A similar explanation was given by several authorities on the Continent—for example, in my own country—and there was agreement so far in believing that the larvæ of the conger and eel would in time be found in quantities in the waters where the old fish live. But of course these suppositions had nothing to go upon. The matter was then allowed to rest for some years, until the international investigations with seagoing steamers and highly developed methods of investigation brought us a step further.

In May 1904, when the Danish research-steamer 'Thor' was on its way from the Faeroes to Iceland, we found a larva of the common eel to the west of the Faeroes over a depth of 1,300 metres. In the same year this quite chance discovery was followed by another, by Mr. Farran, to the west of Ireland, on board the Irish steamer 'Helga.' These larvæ had only been known previously from the Straits of Messina, and their discovery naturally led to a more systematic investigation, which has as far as possible been continued in each of the following years. A very great deal still remains to be done before the biology

of the eels is fully unravelled, but I am able to discuss some of the previously unsolved problems on which our investigations have thrown light: for example, the mode of life of the larval stages and their distribution as compared with the distribution of the older fish. These investigations can best be discussed in chronological order, and this method will also show how we have been obliged slowly and gradually to abandon the prevailing views of the larvæ as larvæ which belong to deep water, or live in the sea-bottom itself, or near to it:—

1904.—In the month of May, as mentioned, we found a *Leptocephalus brevirostris* in the Atlantic, west of the Faeroes.

1905.—In June 1905 we continued our investigations with the 'Thor' from the Faeroes in a southerly direction along the continental slope west of the British Isles. Larvæ of the eel and conger were then found in quantities to the west of the 1,000-metre line, right from the Faeroes to Brittany. On the other hand, none were found to the east of this line, though the same apparatus was used. Thus they were absent from the North Sea, Channel, the Skager Rak, and Danish waters. The natural conclusion I drew from this was that the two species of eels mentioned do not spawn at the British coasts, nor in the North Sea or waters further east, but in the Atlantic to the west of the 1,000-metre line. The stock of eels in these waters must therefore come from the Atlantic Ocean. This was sufficient to show that the conditions in the northern waters was something quite different from those prevailing in the Straits of Messina, where the larvæ of the conger and eel live at the same places as the older fishes.

These investigations of June 1905 also showed that both the conger and eel larvæ are true pelagic animals, having nothing whatsoever to do with the bottom. They live, in fact, in the uppermost 200 metres, and are often found just under the surface. The larvæ found were all fully developed, those of the eel about 75 mm., and those of the conger about double this size—measurements that agree fairly well with the data of the Italian observers. As we did not find the younger developmental stages, the eggs or earliest larvæ, I suggested, influenced by the Italian statements that the eels come into the world and pass the first period of their lives in deep water, that the youngest stages would probably be found deep down in the sea, perhaps at the very bottom. This was one explanation, at any rate, of why we had not obtained them. Our later investigations have shown that this suggestion was not correct.

1906.—The investigations in 1906 were also made in the Atlantic, west of Europe, but extended further to the west out over greater depths than in 1905. We found that the larvæ occurred not only in the belt between 1,000 and 2,000 metres, as in 1905, but also everywhere to the west of 100 metres. They were even found in quantities over the greatest depths of about 5,000 metres. In May the larvæ occurred further out than in September, and the majority of the eel larvæ were in process of metamorphosis in September, whilst none were so far advanced in May. This does not hold good for the conger, however, as the metamorphosing stages were mostly found in May. I was obliged to conclude from the investigations that the eel larvæ come from places where the depth is very great, at least 4,000 to 5,000 metres, and from there move in towards the continental slope. During this movement the metamorphosis of the larvæ begins, that of the eel in the autumn, of the conger somewhat earlier.

After finding the larvæ of the eel over depths of about 5,000 metres, I could no longer believe that this fish spawned at the bottom, and I put forward the suggestion that reproduction takes place far out in the ocean and independent of the bottom. In the Atlantic, north of Spain, we have up to the present found about eight hundred larvæ of the eel and about fifty of the conger. For the Mediterranean, on the other hand, the relative abundance is reversed.

1907.—The year 1907 was used for the collection of material regarding the distribution of the fresh-water eel. The result was that the fresh-water eels are only found in the Northern Atlantic, where their distribution

corresponds fairly exactly to the periphery of the great anticyclonic movement of the currents. In the lands bordering on the Southern Atlantic the fresh-water eel is quite wanting, and this phenomenon I have sought to connect with the presumably unfavourable temperature and salinity of the sea there. •

1908-09 and 1910.—In these years we made two cruises with the 'Thor' in the Mediterranean, the first in winter, the second in summer. On these cruises we found not only all the Leptocephalus species mentioned by the Italian observers, but also the quite young larval stages of several species: for example, of the conger and of the nearly related *Conger mystax*, a species special to the Mediterranean.

Of both these species the author gave a series of figures, showing the developmental stages. They greatly resemble each other in the earliest preleptocephalous stages, and both lack pigment on the sides. They are easily distinguished, however, even in the youngest stages of scarcely one centimetre in length. Thus, *Conger mystax* has a more pointed snout, and the pigment spots on the gut are much denser; further, the position of the anus is quite different. The newly hatched larvæ of the common conger are only found in summer, those of mystax in the beginning of winter, from which we see that the two species spawn at different times of the year.

As our investigations were made both in summer and winter, the growth of the conger larvæ could be followed, and we found that they grew about 5 cm. in the course of six months, and used one to two years for the whole of their larval development; this applies to the common conger.

For the first time, we now learnt where the conger spawn, as we obtained the tiny, newly hatched larvæ, which could not have gone far from the places where they were hatched. The spawning-place is everywhere in the Mediterranean, especially in the deep basins, and further in the Atlantic, west of Gibraltar. Another point of great interest was, that the youngest larvæ of both conger species, of only about 1 cm. in length, were only found at the surface, not in deep water. Here, for the first time, we learnt that not only the fully developed, but also the quite small larvæ, normally belong to the surface layers.

Whether this holds good for all existing eel-fishes I am unable, naturally, to say, but on our cruises in the Mediterranean we found several thousand eggs of eel-fishes, and all these occurred near to the surface. Some species only occurred in the middle of the basins, where the depths are great, others again nearer to the coast, especially in the western part of the Mediterranean, where masses of murænoid eggs were found at the surface over depths of about 100 metres. It appears, therefore, that some species of eels spawn nearer the coasts than others. Unfortunately, I have as yet been as little able as others to determine the species to which the various murænoid eggs belong.

1911.—This year I have not made investigations with the 'Thor,' but several Danish steamers which cross the Atlantic have fished for us with apparatus constructed for the capture of the larger pelagic organisms. In this way we have obtained a very valuable material. Many of the samples taken contained eggs of eel-fishes. I have not been able to determine the species, but these discoveries have great interest in several respects. In the first place, murænoid eggs had previously only been found in the Atlantic only at a single spot off the coast of the United States, whereas it now proves that they occur over enormous distances right across the ocean, at the least 40° N. latitude in a northerly direction. The places where the murænoid eggs have so far been found are represented here on a chart. It will be seen that great interest attaches to these discoveries in another way, in that these murænoid eggs occur for a great part out in the middle of the central parts of the ocean, where the depths are the greatest found in the Atlantic. It follows from this, that the eel-fishes must spawn out here; but as all the eggs are found at the surface,

> it seems reasonable to conclude that they are spawned pelagically without ever having been near the bottom, which is, in fact, 4,000 to 7,000 metres from the surface. How far from the surface the murænoids actually spawn is a question which will be very difficult to solve, as we lack apparatus for the capture of large and swift pelagic fishes.

You will see from what I have said that our investigations have not confirmed the earlier suppositions, that the larval development of the eel-fishes proceeds at the bottom of the sea or in great depths. On the contrary, in the species we are at present acquainted with it proceeds in the uppermost layers. The fact also that such large quantities of murænoid eggs are found at the surface, both in the Mediterranean and the Atlantic, indicates that the same holds good for various other species of eel-fishes.

The charts and preparations exhibited show how far we have come in our investigation of the two eel species which are of the greatest interest for us here in North Europe, the conger and the eel. In the case of the conger, we have come so far that we have all stages, even the youngest, and only the eggs remain to be identified. But in the case of the fresh-water eel, the smallest stages we have found are already over 4 cm. It is therefore impossible as yet to say where the eel spawns in the Atlantic, except that it must be outside the continental slope. Regarding the conger, we know so much more that we can say that it spawns in any case everywhere in the Mediterranean and in the Atlantic west of the Mediterranean.

How far to the west in the Atlantic, I do not know; I can only say that the place furthest west where we have found the full-grown larvæ of *Conger vulgaris*, lies at 30° W. longitude, in the neighbourhood of the Azores.

I shall not enter upon further details at present. You will have seen that there is still much to explain in these problems, but you will perhaps also have obtained the impression that the question of the biology and reproduction of the conger and eel is extremely difficult, much more complicated than it seemed to be after the publication of the Italian discoveries. It has only been with the help of our good ship and our good apparatus that we have been able to win any result from these prolonged investigations. One way or another we hope to continue these, and thus be able to make still further progress.

4. *Note on the Occurrence of* Amphidinium. *By* Professor W. A. Herdman, *F.R.S.*

5. *The Lantern of Aristotle as an Organ of Locomotion.* (Echinus esculentus *and* E. miliaris.) *By* James F. Gemmill, *M.A., M.D., D.Sc.*

I. Action out of water. II. Action under water. III. Other allied activities. IV. Methods of observation.

Summary.

I. Reference to previous account by Romanes and Ewart. There occurs a rhythmic swinging movement of the lantern. Progression is by a series of steps or lurches which are more or less sharply defined. In each step the urchin is raised on the tips of the teeth and a forward impulse given, (*a*) by strong pushing or poling on the part of the lantern, (*b*) by similar but usually less effective pushing on the part of the spines, and (*c*), after a certain stage, by the influence of gravity. The lantern is then retracted and the teeth swing forward into position for initiating a new lurch. Length and rhythm of step in urchins of various sizes. Recording surfaces. Inversion, equatorial section, and loading experiments. Muscles involved. Relation of rotation to progression. Causes of rotation. Locomotion possible even in the absence of spines.

II. Lantern not needed for ordinary locomotion over more or less horizontal

surfaces under water. Various conditions, normal and experimental, in which it is, however, employed with effect.

III. The locomotor action of the lantern is a particular manifestation of a rhythmic functional activity, which can also subserve feeding, boring, respiration, and possibly also the maintenance of physiological turgescence in various internal cavities.

6. *The Dorsal Vibratile Fin of the Rockling* (Motella).
By J. STUART THOMSON, *Ph.D., F.R.S.E.*

It has been suggested by Bogoljubsky and others that the dorsal vibratile fin of Motella is a 'lure,' functioning in a somewhat similar manner to the anterior filamentous process of the fishing-frog, *Lophius piscatorius*.

The object of the present paper is to show that the function of the vibratile rays is to produce a current of water over numerous terminal or taste buds situated on the skin in that region of the body. This part thus functions as a highly efficient gustatory organ. These taste organs are distinguished from the neuromasts or lateral line organs by the following points: (1) The sensory cells extend from the external ectoderm to the internal limiting membrane; (2) the organs are not enclosed in pits, canals, or tubes, and (3) they are innervated by the recurrent facial (ramus lateralis accessorius), which has its root in the facial lobe of the medulla. The facial lobe has been described by Herrick as part of the gustatory tract.

While it is more than probable that in certain cases the vibratile motion of the free rays may attract animals to the proximity of the taste buds of this region, and thus bring food within the sphere of physiological action, in other cases it is impossible that this apparatus could function as a 'lure,' as the food in these instances consists of animals which have slight or no visual power. It is evident that in many cases the animals upon which the Rockling feeds come quite accidentally near the taste glands, and the current of water produced by the vibrating rays aids in locating or detecting food.

One has to distinguish in fishes (1) an olfactory reaction, *i.e.*, an aimless circling movement; (2) a gustatory reaction, *i.e.*, a sharp turn of the body and instantaneous seizing of the bait; and (3) a tactile reaction.

From the author's experiments there could be no doubt of the existence of a purely gustatory reaction. Some of the most successful responses were obtained on placing Arenicola in proximity, but not in actual contact, with the taste buds of the region under consideration.

Bateson has previously noted the presence and physiological significance of terminal buds on the barbules and pelvic fins of Motella.

7. *Variation in a Medusa. By* C. L. BOULENGER, *M.A.*

8. *Report on the Occupation of a Table at the Zoological Station at Naples.* See Reports, p. 119.

9. *Report on the Index Animalium.*—See Reports, p. 120.

10. *Third Report on the Feeding Habits of British Birds.* See Reports, p. 128.

11. *Report on the Biological Problems incidental to the Belmullet Whaling Station.*—See Reports, p. 121.

12. *Report on the Mammalian Fauna in the Miocene Deposits of the Bugti Hills, Baluchistan.*—See Reports, p. 127.

13. *Twenty-first Report on the Zoology of the Sandwich Islands.* See Reports, p. 128.

14. *Report on Zoology Organisation.*—See Reports, p. 127.

15. *Report on the Occupation of a Table at the Marine Laboratory, Plymouth.* See Reports, p. 129.

16. *Fourth Report on Experiments in Inheritance.* See Reports, p. 125.

17. *Report on the Formulation of a Definite System on which Collectors should record their Captures.*—See Reports, p. 126.

18. *Some recent Work on Sex.* *By* GEOFFREY SMITH.

In a communication made to the British Association last year the author put forward a theory to account for the effect of the parasite *Sacculina* upon the sexual characters of its host, *Inachus*, according to which the development of the adult female characters in infected individuals of both sexes was held to be due to the production in excess of a yolk or fatty material in the blood similar to that which is stored in the ovary of a normal adult female. It was shown that the roots of the *Sacculina* actually take up such a fatty substance from the blood of the host, and it was supposed on the analogy of an immunity reaction that the fixation of the fatty material by the parasite stimulated its constant production, and that the presence of this substance constantly circulating in the blood was the stimulus for the production of the female characteristics. Evidence bearing on this theory and to some extent confirming it has been obtained by G. C. Robson at Naples. Following and extending the observations of Heim, he finds that in normal *Inachus* the blood may be coloured orange or pink by the presence of a lipochrome in solution. Lipochromes invariably accompany fatty substances, in which they are soluble; we may therefore suppose that when lipochrome is present in the blood it is accompanying fatty materials. Now it has been found that the presence of lipochrome in the blood is particularly characteristic of female crabs at the time that the ovary is maturing, when a transference of fatty material and of lipochrome to the ovary from the liver is observed to be taking place. In *Inachus* of both sexes infected with *Sacculina* we also get a development of lipochrome in the blood equal to that which occurs in breeding females. This fact is therefore in complete agreement with the theory outlined last year. The matter is, however, complicated by the fact that lipochrome is developed in the blood of normal *Inachus* of both sexes which are about to moult, so that it cannot be held that the mere presence of the lipochrome in the blood is the stimulus for the development of the female characters. The proof, however, is furnished that the presence of *Sacculina* profoundly influences the fat metabolism of its host. Work is proceeding on these lines. Some observations have also been made by the author upon the fluctuations in growth of the comb of fowls which show the close connection between fat metabolism and the development of the female characteristics.

It was found by a long series of measurements of the combs of hens, that the combs are continually fluctuating in size, the fluctuations being exceedingly rapid and between very wide limits, a comb increasing or decreasing to as much as 200 per cent. of its area in three weeks. It was found that the rapid increase of the comb invariably takes place just before a period of egg-laying begins. An examination of the structure of the hen's comb shows that it is composed essentially of two walls of fibrous and vascular connective tissue between which there is a loose core of connective tissue which at the period of egg-laying becomes infiltrated with fat, and this rapid fat-infiltration is the cause of the sudden increase of the mass of the comb. Now this fat-infiltration and increase of the comb takes place when the ovary is storing up large quantities of yolk, *i.e.*, at a period when large quantities of fatty material are being conveyed in the blood to the ovary. We have therefore an instance of a simultaneous effect upon the ovary and a secondary sexual character brought about by the presence of an excess of fatty material in the blood. This is probably analogous to what happens in *Sacculina* and *Inachus*.

19. *The Effect of* Sacculina *upon the Fat-metabolism of the Crab* Inachus mauritanicus. *By* G. C. Robson.

These observations were undertaken to extend Geoffrey Smith's theory of the *Sacculina* acting as a stimulus for the production in the host-crab of a yolk-forming substance similar to that developed in the normal ♀ at sexual maturity, which substance conditions the appearance of the secondary sexual characters. Heim's observations on the blood-lipochrome of various Decapoda. Importance of these to the theory of Smith. The blood-lipochromes of Inachus. Their behaviour and occurrence in normal, moulting, and infected crabs. Their relation to the fat metabolism. The Decapod liver as a fat storing organ - in normal, moulting, and infected animals. The origin of the fat supply in relation to infection by Sacculina. The destination of the fat of moulting, sexually mature ♀ and infected crabs. The ultimate fate of infected crabs. Main conclusions :—

(1) The infection by *Sacculina* induces the maintenance of a quantity of fatty substance in its host's liver and blood, more constant or more excessive than under normal circumstances.

(2) This condition resembles that found in normal ♀ and ♂ preparing to moult, and in sexually mature ♀ ; the ultimate destination of the fat being functionally similar in the case of the mature ♀ and the infected crabs.

(3) In all probability the fate of infected crabs is death from starvation owing to their inability to obtain enough fatty material for their own immediate needs.

20. *On the Experimental Control of Dominance in Echinoderm Hybrids. By* H. M. Fuchs, *B.A.*

In 1909 and 1910 D. H. Tennent, working at Tortugas, crossed *Hipponöe* ♂ × *Toxopneustes* ♀, and *Toxopneustes* ♂ × *Hipponöe* ♀, getting in both cases larvæ with a preponderance of *Hipponöe* characters. By keeping the eggs in sea-water with increased and decreased concentrations of OH ions during the segmentation period, he claims to have altered this dominance. A decrease of OH ions gave *Toxopneustes* characters. The skeletal characters were used as criteria, the most important being the presence of fenestrated rods in the postoral arms of *Hipponöe* and of simple rods in *Toxopneustes*. Tennent said, 'I shall regard the presence of more than one rod in the postoral arms as an indication of *Hipponöe* influence.' Now it is well known that pathological larvæ always tend to grow extra rods in the arms, and a large number of Tennent's figures show irregular shapes. He points out that his controls did not show multiple rods, but these were not in an abnormal environment. The decrease of OH ions may have swung the dominance to the *Toxopneustes* side, or it may have had a directly pathological effect on the hybrids.

At the suggestion of Dr. Cresswell Shearer, the author repeated Tennent's

work with the Echinoids found at Plymouth, using the later and more definite larval characters as criteria. The pluteus of *Echinus acutus* at about a month old has both anterior and posterior ciliated epaulettes, whereas that of *E. miliaris* lacks the posterior epaulettes. On the other hand, *E. miliaris* possesses two pairs of green pigment masses in the anterior epaulettes, which are absent from *E. acutus*. Shearer and de Morgan have found that when these forms are crossed the characters of the hybrid larvæ are always the same as those of the mother.

The writer crossed *E. acutus* ♂ × *E. miliaris* ♀ and *E. miliaris* ♂ × *E. acutus* ♀ in sea-water, the OH ion concentration of which had been raised by NaOH and lowered by HCl and by acetic acid. As soon as the blastulæ swam to the surface they were transferred to normal sea-water. A large number of skeletons were drawn, no selection being made except that misshapen larvæ were omitted. Of the latter there were always more than when the crosses were made in normal water. The skeleton drawings showed that there had been no effect on the inheritance. At a month old and later a large number of plutei were examined and in all cases they had wholly maternal epaulettes and pigment masses.

If Tennent's result be true it is of importance to determine whether it is of general application. The failure to bring it about at Plymouth in no way disproves his case, since we start here on a different basis. He started with a dominance of one species over another, whereas at Plymouth there is a maternal dominance. In the latter case, however, an alteration in the concentration of OH ions in the external medium has *no* effect on the inheritance.

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21. *The Problem of Sex Determination in* Dinophilus gyrociliatus.

By C. Shearer, *M.A.*

The group of primitive Annelids *Dinophilus* comprises some eight or nine species. They are remarkable for the fact that some show a well-marked sexual dimorphism, in which the male is rudimentary, without any mouth or digestive system, while in others the sexes are the same size and exhibit no signs of this dimorphism. The group as a class therefore is readily divisible into two sub divisions, in one of which all the species are sexually dimorphic, unpigmented, and colourless, while in the other they are highly pigmented, of a bright red colour, and sexually monomorphic. The former may be called the Leucodinophilidæ, while the latter may be called the Erythrodinophilidæ. The known species, many of which are of very doubtful specific value, may be arranged under these two subdivisions as follows:—

Leucodinophilidæ.

1. *Dinophilus gyrociliatus.*
2. ,, *Conklini.*
3. ,, *apatris.*
4. ,, *metameroides.*
5. ,, *pygmoeus.*

Erythrodinophilidæ.

6. *Dinophilus vorticoides.*
7. ,, *Gardineri.*
8. ,, *taeniatus.*
9. ,, *gigas.*

Of the Leucodinophilidæ the first three species, *D. gyrociliatus*, *D. Conklini*, and *D. apatris*, are closely related, and are probably one and the same species, and the form on which the following work has been done is one of them, though exactly which of the three I have been unable to decide. As the oldest of these names is *D. gyrociliatus*, I have placed my species under this heading. It was obtained some three years ago from some sandy material collected in Plymouth Sound. I introduced it subsequently into the tanks of the Plymouth Laboratory, where it has since established itself and breeds.

Korschelt was the first to point out that a marked sexual dimorphism is present in *D. apatris*, where the male is small and rudimentary. He also observed that the female laid two kinds of eggs, some of which were small and are destined to give rise to the rudimentary males, while others almost six times the size of the small ones and also more numerous, are to give rise to the large females. Here was apparently a clear case in which we get sex deter-

mination in the ovary long before fertilisation. It was with the object of more carefully investigating this matter that the present work was undertaken.

The two kinds of eggs are laid together at the same time, as Korschelt has determined, and in a few days the male egg gives rise to the rudimentary male, which at the time it is ready to leave the egg capsule is fully grown and sexually mature, while the female at the moment she leaves the capsule is small and immature. As the young worms develop in the egg capsule they are seen to spin round, and as the moment for hatching approaches they become very active. Shortly before the female leaves the capsule, the small males are seen actively copulating with them, so that each female when it leaves has already been fertilised.

This process can be easily observed under the low power of the microscope, and the actual passage of the sperm from the testes of the male into the body of the female witnessed in the living state. Each female is seen to carry a small mass of active sperms on the ventral side of the gut, at the point of junction of stomach and intestine. If sections are cut of the female at this stage, it is seen that although the sperms are collected where the future ovary and ova will appear, no trace of them can at this time be detected. The ova first appear at a much later date, when the female has grown very considerably in size. They are then seen as a few small nuclei, which grow rapidly. Shortly after the female germ-cells appear it is seen that each one is joined by a spermatozoon, the head of which has become embedded in, or attached to, its nuclear wall, so that ultimately the nucleus of each primitive ovum is seen to be composed of one part, derived from the spermatazoon and the other part of the female portion. These two elements of the nucleus never fuse, but retain their individuality throughout all the various oögonial divisions. The double nucleus divides amitotically; each half separately. In the majority of these divisions the male and female portions of the nucleus divide equally, so that a similar quantity of nuclear material, both male and female, goes into each daughter cell. There are probably about forty to fifty oögonial divisions in all. In all these the male and female portions of the nucleus divide and move apart simultaneously. Now and again, however, the female half of the nucleus seems to divide before the male portion, so that the male portion gets left behind and is shut off entirely in one of the daughter cells. Therefore of the two resulting daughter cells one has the whole of the male part of the original nucleus and its share of the female portion, while the other has only its half of the female and no male substance. This appears to be the sex determining factor; for of these two daughter cells, the one that has received the whole of the male element and the female element becomes the female, while that which has received the female portion alone, becomes the male. Both these two kinds of eggs, once the sex determining division has taken place, grow rapidly. They seem to do this through the power of absorbing and building up into themselves all the other immature egg cells with which they come in contact, and in which the divisions of the two portions of the male and female substance have been equal. The outcome of this process is that the male egg is not fertilised, while the female egg is fertilised. It is, however, impossible to speak of the male egg as unfertilised, as it has been directly under the influence of the sperm in all the oogonial divisions previous to the sex determining one. It is only in the late stages shortly before the egg is laid that the two parts of the nucleus fuse beyond recognition. As the two kinds of eggs, male and female, are not found in equal numbers, it is probable that one of them undergoes division in turn. and I am inclined to believe that this is the female, as the female eggs are laid in the proportion of three to one of the male. I have not decided this point. The naturation divisions have been studies in both eggs, but I desire to withhold any statements with regard to them till I have studied them more thoroughly.

MONDAY, SEPTEMBER 4.

The following Papers were read :—

1. *Notes on a Trypansome found in a Sheep Tick, and its probable connection with the Disease known as Louping-ill.* *By* Major C. F. Bishop, *R.A.*

In previous investigations of louping-ill many possible causes have been suggested, tested, and either discarded or left unproven.

Until 1902 a considerable amount of attention was paid to the 'Tick Theory,' which held that, as louping-ill appears and disappears at approximately the beginning and end respectively of the sheep tick season, there was great probability that the ticks were closely connected with the propagation of the disease.

In December 1901 the Board of Agriculture appointed a Committee to inquire into the causes of both louping-ill and braxy, and after four years of investigation and experiments the Committee issued a lengthy report in 1906, announcing that they had discovered, and proved, the cause of louping ill to be a bacillus, which during certain months of the year, namely, April and May, attacks the intestine of the sheep, thereby causing the disease, although during other months the sheep's blood is able to resist the harmful powers of the germ.

The Committee also announced that they had inquired into and tested the 'Tick Theory,' and had come to the conclusion that it was quite untenable They sum it up as the sort of unscientific suggestion that farmers would naturally make, founded upon the mere coincidence that ticks and louping-ill often occur together.

This report has, since 1906, been the last word on louping-ill; the established truth concerning the disease.

Early this year, at the suggestion of Professor Meek, F.Z.S., who in 1896 and 1897 was a strong upholder of the 'Tick Theory,' the writer began a small investigation of louping-ill, with the idea of searching for some blood parasite which might prove to be the true cause of the disease, and spent five days at a farm in the louping-ill district, near Bellingham, collecting ticks off diseased sheep, and specimens of blood taken direct from the living animals, or from their internal organs after death.

The first result obtained was the discovery of a trypansome, on a slide made of blood squeezed from a tick, taken off a sheep, said to be a typical case of louping-ill.

The trypansome lay in a good position on the slide, and had stained excellently with Leishman's stain. Its dimensions are: Length (in a straight line), 21·75 microns; greatest breadth, 1·5 micron; nucleus, length, 3 microns; breadth 1 micron; centre of nucleus, 9·75 microns from posterior extremity; the blepharoplast is large, and lies anterior to the nucleus.

No trypansomes having yet been found in any of the sheep examined, there is no proof that the one found in the tick had been sucked from a sheep; but, from the frequent association of these parasites with diseases in horses and cattle, there is a probability of its being connected with the disease of the sheep.

The next result obtained by the author was the discovery of certain forms, apparently blood parasites, in a specimen of blood from the sheep off which the tick containing the trypansome was taken.

Subsequent examination showed these same forms to be present in the blood of five other sheep, all of which were said to be cases of louping-ill.

Examination of blood obtained in Tynemouth, from healthy sheep, failed to discover any such form in it.

The forms have not yet been sufficiently under observation for the writer to venture very definite opinions regarding them; but they are found free in the blood plasma, apparently flagellates, and, very possibly, may be allied to the trypansome in the tick.

The author is aware that the small results as yet obtained by him prove practically nothing, but he considers that they are enough to throw considerable doubt on the present established theory as to the cause of louping-ill, and its method of propagation. He recognises that the work of a thorough re-investigation of the disease would require far more time and opportunities than are at

his command; and, without relinquishing the work himself, he wishes to point out to others interested in such research work, that there is a probable trypansomic disease here in England at present uninvestigated.

2. *Recent Discoveries in Mimicry, Protective Resemblance, &c., in African Butterflies and Moths. By* Professor E. B. POULTON, *F.R.S.*

3. *The Extinct Reptiles of the Oxford Clay of Peterborough. By* Dr. C. W. ANDREWS, *F.R.S.*

TUESDAY, SEPTEMBER 5.

The following Papers were read :—

1. *On the Distribution of Tracheæ to the Scent Patches in Lepidoptera. By* Dr. J. A. DIXEY, *F.R.S.*

The circumscribed patches of scent-distributing scales which occur in the males of many butterflies belonging to the group of Pierinæ, are furnished with a special supply of tracheæ derived from a neighbouring so-called 'vein.' This feature has been observed in members of the genera *Colias*, *Teracolus*, and *Catopsilia*; but not in *Dismorphia*, where similar patches are present. The significance of this special supply of air-passages is doubtful, especially as the ultimate tracheal branches have not been traced with certainty; but the suggestion is hazarded that their function may possibly be to assist mechanically the liberation of perfume from the specialised scales of the patch, by the impulse of air acting as a *visaatergo.*

2. *The Annual Cycle of Changes in the Genital Glands of* Echinocardium cordatum. *By* Professor MAURICE CAULLERY.

From July to the end of the year the genital glands of this Echinoid are almost entirely composed of large cells with parietal cytoplasm enclosing numerous spherules of reserve substance and with a large vacuole containing a hyaline liquid. In males these cells present, among the spherules of reserve material, numerous spermatozoa, agglutinated into packets, which have been ingested (phagocytosis); in females there are, between the cells, fragments of ovules (cytoplasm or nucleus) in degeneration; at the periphery there are either young ovules or small masses of spermatogonia. The growth of the genital products is effected (in part owing to the presence of the reserve-laden cells) at the end of winter, and the period of maturity, at Wimereux, extends from April to the end of May, or even further. The reserve-containing cells are gradually pushed towards the centre of the acini and disappear; but while in some localities, such as Naples, the disappearance of these cells is practically complete, at Wimereux they do not so fully disappear: there remains always a certain amount of this tissue. There are thus, from the physiological aspect, certain interesting differences.

At the end of May there is a rapid and active change in the genital glands. Up to that time there have been formed, in the testis, for instance, only sexual cells closely appressed; henceforward there are produced numerous cells, each of which elaborates groups of granules and contains a large vacuole. This is the new reserve tissue which has made its appearance and rapidly forms a continuous peripheral layer. Soon, by the end of June, the sexual elements in course of formation—young eggs or stages of growth of spermatozoa—exhibit

signs of degeneration, *e.g.*, fragmentation of the ovules, pycnosis of the spermatogonia. Ripe products are still for some time expelled to the exterior, but from July the emission ceases, and the spermatozoa remaining in the testis become agglutinated and phagocytosis occurs; they are ingested by the reserve cells. These cells gradually occupy the whole genital gland.

Other Echinoids may present analogous phenomena, while in Asteroids, where there is no reserve tissue, the genital glands, after having almost filled the arms, become so much reduced as to be nearly imperceptible.

3. *British Symphyla* (Scolopendrellidæ).

By RICHARD S. BAGNALL, *F.L.S.*

Up to a year ago only one species, a *Scutigerella*, but more commonly known as *Scolopendrella immaculata* (Newport), was known to British naturalists. In 1904 H. J. Hansen monographed the order, recognising eight European forms, some of which were somewhat widely distributed. Of these, six have occurred in the North of England (that is all but *Scutigerella nivea* (Scopole), and *Scolopendrella microcolpa* (Muhr), and in addition four other well-defined and apparently new forms. This material forms the subject of a 'Synopsis of the British Symphyla,' which will shortly be published in the Transactions of the Natural History Society of Northumberland and Durham.

Drawings demonstrated the strong characters which separated the two genera, and the equally good characters of the various groups and species as follows:

Genus SCUTIGERELLA.

Group I.	Group II.
S. immaculata (Newport).	*S. hanseni* (Bagnall).
S biscutata (Bagnall).	*S. caldaria* (Hansen).

Genus SCOLOPENDRELLA.

Group I.	Group III.
S. notacantha (Gervais).	*S. isabellæ* (Graesi).
	S. isabellæ, var. *dunelmensis* (Bagnall).
Group II.	*S. horrida* (Bagnall).
	S. vulgaris (Hansen).
S subnuda (Hansen).	*S delicatula* (Bagnall).
	S. minutissima (Bagnall).

NEW DIPLOPODS.

The following Diplopods were recorded from the North of England, each representing a genus previously unknown to the British fauna:—

- *Brachychæteumidæ* nov. fam. (Verhoeff).
  - *Brachychæteuma bagnalli* g. et. sp. n. (Verhoeff), 1 ♂.
- *Polydesmidæ.*
  - *Titanosoma jurassicum* (Verhoeff). Numerous ♀s., described last year from a single example taken in the Valley of the Danube.
- *Chordeumidæ.*
  - *Microchordeuma* sp. 1 ♀.
- *Julidæ.*
  - *Isobates varicornis* (Koch). Several ♀s and ♂s.
  - *Napoiulus* sp. (probably *palmatus*, Nemec). Several ♀s.

PAUROPODS.

An apparently new *Pauropod* belonging to the family Eurypauropodidæ was described from the North of England, this being the first British example of that family, and differing in a striking manner from the species known to the author.

3. *Momentum in Evolution.* *By* Professor ARTHUR DENDY, *F.R.S.*

See Reports, p. 277.

4. *The Food-supply of Aquatic Animals.* *By* Dr. W. J. DAKIN.

In 1907 an extremely interesting paper appeared by August Putter of Gottingen. The author pointed out that a very general assumption had been made by biologists and physiologists to the effect that aquatic animals fed, like most terrestrial animals, on solid food. The minute algæ of the phytoplankton were, for example, considered to be the ultimate source of food, and the animals of the zooplankton fed directly upon these or upon microscopic animals, which in their turn fed upon the plants. Fixed animals like sponges and zoophytes, or creatures like lamellibranchs, were dependent upon the organisms filtered or removed from currents of sea-water. One reason for this unquestioned assumption was that no other source of food-material was apparent. If it could be proved, therefore, that large quantities of organic food-material exist in the sea in some other form, it would be necessary thoroughly to revise our conceptions of the biology of aquatic organisms.

The first experiments made by Putter were for the purpose of determining whether or no an organic carbon compound occurred in the fluid in which aquatic animals lived. The result was startling, for he found that sea-water contained 24,000 times more carbon per litre than was present in the organisms (plankton) of the same volume of water. This was his starting-point, and he has endeavoured to show that the sea or fresh water is more or less a nutrient fluid, which is more important altogether than solid food in the physiology of aquatic organisms.

Since the publication of the first paper it has been shown that Putter's analyses were not quite correct, and, further, that many mixed planktonic forms were not considered in early determinations, for they were too small to be captured by apparatus then used.

Pütter has been able, however, with the latest determinations, to show that there is still more organic carbon present in solution than in the plankton.

There is no reason whatever against aquatic animals using food in solution, and it is important, therefore, to find out whether they *do* use it.

The first and most important facts supporting the theory are the results of experiments made to determine the amount of carbon and oxygen required by certain animals per day to cover the loss due to metabolism. A specimen of the sponge Suberites, of 60 gr. weight, requires as food 22 m.g. carbon per day. To provide this amount the sponge would need to capture

1,480,000,000 *Sceletonema costatum*, or
7,400,000,000 *Thalassiosira nana.*

It would have to filter several thousand times its own volume of water per hour to obtain enough food—an altogether unthinkable piece of work.

If the food in solution in the sea-water was used, a much more rational quantity of water would suffice and all the conditions would be more favourable.

The same experiments have been carried out on Cucumaria and other animals with the same results, and if calculations are made to determine the food requirements of aquatic organisms, the general result is to find that the large quantity of food needed is beyond the powers of the animals concerned if it can only be solid food. For example, according to Winterstein, a Rhizostoma of 232 c.c. volume uses per day, at 26°, 122 m.g. of oxygen. This corresponds to a food-supply of

24,000 Temorella or
490,000 Nauplii.

The larger Rhizostoma frequently caught would require

10,600 Calanus.
392,000 Temorella.
2,630,000 Orthona.
7,820,000 Nauplii per day.

It is quite impossible for such large quantities to be caught and equally strange that remains of the creatures are so rarely found if they have been captured as food. Putter has given figures for Anthozoa, Rotifera, Crustacea, Tunicata, and even fishes.

The figures for the entomostraca are particularly interesting, because the copepoda are supposed to play such an important part in the economics of the sea. For a long time the actual solid food of the copepoda was unknown. The writer was able, after the examination of a large number of individuals, to show that one could find remains of diatoms, Peridinium, and very small naked flagellates which passed through the finest silk. Putter's calculations demand, however, for a Calanus, 9,750,000 *Thalassiosira nana* per day! He asks if it is possible for such a quantity of food to be captured by a copepod.

It has been found that gold-fish living in tap-water without solid food can exist for forty-one days, and during this period the amount of oxygen consumed is equivalent to that required if calculations are made from the loss of weight of the fish. If, now, organic substances in solution are added to the water, the same species live seventy-eight days, and the oxygen consumed per fish is *in excess* of the amount calculated from the loss in weight—*i.e.*, the oxygen must have been used for the oxidation of substances *in addition to those stored in the tissues.*

We may divide the plankton organisms into two contingents, that of the producers and that of the consumers. To the first category belong the organisms of the phytoplankton which make use of dissolved inorganic substances, and to the second the animals. Now calculations have shown that the 'producers' are insufficient for the 'consumers.' This is a very powerful argument in favour of Pütter's theory, and even the Kiel planktologists (who have been in general against Putter from the first) have had to seek for another source of food for the zooplankton (Lohmann's detritus theory).

One finds that the copepoda are usually most abundant *after* the maxima of the phytoplankton. This has been accounted for by some workers by assuming that the increasing copepoda destroy the phytoplankton. May it not be that the increase of the copepoda is due to the large quantities of available dissolved organic matter due to the death and disintegration as well as to the destructive metabolism of the plants of the antecedent phytoplankton maximum? Only a few weeks ago attention was drawn to the fact that in the high Alpine lakes there exists an outstanding production of zooplanktonic organisms. What is the source of food of these Alpine Crustacea and Rotifera? The lakes are almost deserts as far as phytoplankton is concerned. Pütter's theory is the only solution of the riddle.

Finally there must be taken into account the great difficulty, so often experienced, of finding the remains of organised food in the alimentary canals of many aquatic organisms. We have, too, crabs living in sponges, and with only filtered water at their disposal, and Knörrich and Wolff have been able to keep Daphnids living and growing in solutions containing *only* dissolved food-matter.

There are many other points which may be cited in favour of the theory, and much which may be brought forward against it. The latter I have left for purposes of discussion. I myself believe that, though solid food is necessary, yet food in solution also forms part of the normal food-supply.

5. *On the Systematic Position of the Marsipobranchii.*

By W. N. F. Woodland.

A short summary of the arguments demonstrating that the Marsipobranchs are primitively agnathostomatous animals will alone be provided here. The result of recent research on the innervation, musculature, and development of the Marsipobranch head has been entirely to demolish theories which regard the subocular arch and 'lingual' cartilages ('piston' cartilages—Bujor) of Marsipobranchs as respectively homologous with the p.p.q. bar and glosso-hyal element of Gnathostomes. That the subocular arch is not a true p.p.q. bar is alone proved by the well-known facts that the maxillo-mandibular nerves pass ven-

trally to the arch instead of dorsally, and that the anterior palatine branch of the trigeminus runs dorsal to the so-called palatine instead of ventral to it, the so-called palatine being a mere anterior extension of the trabecula (Allis) The so-called hyoid process ('styloid' in Petromyzon) also cannot be so termed, since the hyomandibular nerve passes *behind* the cartilage (Allis). As to the piston cartilage, since its musculature is innervated by the *mandibularis* nerve and not by the hypoglossal, modern upholders of Gnathostome ancestry have revived the opinion that the piston cartilage represents the much-modified and displaced mandible of Gnathostomes, the so called hyoid representing a quadrate element. The grounds upon which this comparison is made are (1) identity of position, (2) innervation of the piston musculature, and (3) the tacit and quite unwarranted assumption that the piston cartilage, if proved to be homologous with Meckel's cartilage of Gnathostomes, was itself a biting apparatus in ancestral Marsipobranchs. With regard to (1) mere position is no criterion of homology, yet, after all, similarity of position is the only basis for the great majority of the assertions of Ayers and Jackson, and Stockard's supposed demonstration of the homology solely amounts to proving that the piston cartilage *arises* in the position in which it is found in the adult (!), no evidence being adduced to show that the piston cartilage is ever paired (an interior forking cannot be regarded as evidence), that it ever has any connection with the quadrate element, or that it even at any stage borders the sides of the mouth as mandibular elements should. Respecting (2), it is obvious that this evidence, regarded by the authors named as conclusive, is in reality only an additional illustration of the truism that muscles formed from the same region of the gut wall are in all Craniates innervated by the same nerves (strictly speaking, in this particular case, the mandibular nerve supplying these muscles is not exactly homologous with the Gnathostome *mandibularis*—P. Furbringer, Johnston). In what manner this evidence can be held to show that the piston cartilage was once a mandible it is difficult to conceive. (3) Requires no comment. The evidence adduced in favour of the Gnathostome ancestry of Marsipobranchs being thus inconclusive, and all authorities being in agreement concerning the exceedingly primitive nature of the group, it follows that if there exist facts tending to show that jaws could never have existed, great weight must be attached to this evidence. (1) The development of both the piston musculature (Bujor, Dean) and cartilage (Stockard) in the mid-ventral line is quite inconsistent with the view that these structures were formerly paired laterally-placed mandibular muscles and rami. (2) In the Myxinoids there is no hypoglossal musculature or nerve (Worthington, Cole), the myotomes extending laterally in an unbroken series to the extreme end of the head. This persistence of the primitive condition (shown to be primitive by the innervation) proves that a jaw apparatus could never have been developed, since in all Gnathostomes the presence of the laterally developed jaws and the large muscles which work them render it impossible for myotomes to persist in this region. On the other hand, a rasping dentigerous piston worked by a mid-ventral musculature does not interfere with lateral myotomes. In the Petromyzontes the development of the gill-clefts has (unlike those of Bdellostoma) interfered with the ventral growth of the myotomes in the branchial region, the result being the development and growing forwards under the row of gill-apertures of a sub-branchial myotome musculature innervated by a hypoglossal nerve and homologous with the hypoglossal musculature of Gnathostomes (Neal, Johnston). In Petromyzontes, however, this subbranchial musculature extends right up to the buccal funnel, retains its parietolateral position, and has no connection with a tongue apparatus, being alone concerned with the flexion of the body anteriorly in swimming. These facts I think also prove that in Petromyzontes a jaw apparatus can never have been present, since had this been the case these lateral sub-branchial myotomes would have become much reduced, restricted to the mid-ventral line, and probably specialised to form a true mid-ventral tongue musculature as they have in all Gnathostomes. To assume that they have secondarily reacquired their primitive appearance is unwarranted, and to assume that they never were specialised as hypoglossal musculature is, to judge from existing Gnathostomes, to assume that jaws were never present. Moreover, the presence of a true tongue musculature would have prohibited the evolution of a piston musculature. (3) According to the views held by most leading authorities, the piston cartilages of the Myxinoids

and Petromyzontes are non-homologous structures, and, if this be the case, it necessarily follows that in one of the two groups the piston cartilages cannot represent the modified primitive Gnathostome mandible (despite the *mandibularis*-innervated musculature!). Thus, even according to Ayers and Jackson, the piston cartilage of Petromyzon represents the posterior segment of the basal plate of Bdellostoma, and this, according to them, being composed 'only of chondroidal tissue and . . . not homologous with any part of the visceral arches,' it necessarily follows, on their own showing, that the conclusion just stated applies to the Petromyzontes—the Petromyzontes cannot possess the homologue of a mandible. Further, seeing that the piston cartilages of Myxinoids are not more obviously a modified mandible than the equivalent structures in Petromyzontes, there is thus left no reason for supposing that the piston cartilages are in either case so derived. Since it is impossible to assume that in one group the mandible and in the other accessory cartilages (*e.g.*, labials) respectively produced the piston skeleton, it must be concluded that jaws were absent in the ancestors of both groups. (4) The assumption of a gnathostomatous Marsipobranch ancestor ignores the primitive membranous condition of the cranium and the feeble development of the parachordals and trabeculæ, parts which must be strongly built in order to bear jaws, and there is no more reason to suppose that these parts have secondarily degenerated in the Marsipobranchs than it can be supposed that the low degree of cephalisation (*i.e.*, absence of occiput, a feature also correlated with the absence of jaws) is secondary. (5) In view of the undoubted validity of Balfour's well-known dictum that 'if the primitive Cyclostomes had not true branchial bars, they could not have had jaws, because jaws are essentially developed from the mandibular branchial arch,' the question as to whether or not the branchial skeleton of Marsipobranchs is homologous with the branchial skeleton of Gnathostomes becomes of importance. Balfour's contention that the Marsipobranchs do not possess and never have possessed a branchial skeleton homologous with that of Gnathostomes is supported by the facts that the branchial basket is developed external to the ventral aorta and the gill-vessels instead of internal as in Gnathostomes, that it is developed long before the subocular arch (p.p.q. bar on the hypothesis), and apparently quite independently of it (*cf.* Gnathostomes in which the jaw and hyoid arches are the first members of the visceral series to appear, even in the degenerate Sturgeon), that it is only developed to any extent in the Petromyzontes, in which the gill-apertures serve for ingress as well as egress of water, and not in Bdellostoma, in which the water enters the gill pouches *viâ* the hypophysial duct, and that a series of parietal myotomes extend underneath the entire series of gill-apertures to the mouth in both Myxinoids and Petromyzontes (the presence of these myotomes implying that vertically elongated gill-clefts, and therefore elongated segmented branchial bars, were never present in Marsipobranchs). Viewing the system of visceral arches as a whole, it is incredible, if Marsipobranchs have originated from a gnathostomatous stock, that the first two visceral arches should exhibit the differences in development (in time and form) and relationships to nerves and muscles that the subocular arch, piston cartilages, styloid cartilage, &c., do when compared with the jaw and hyoid arches of Gnathostomes. If ancestral Marsipobranchs possessed jaws, they were not the jaws of existing Gnathostomes. The only alternative to the branchial arch theory of the origin of jaws is the cirrhostomial theory (Pollard), but to adopt this is to adopt Balfour's contention.

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6. *Discussion on the Origin of Mammals.*

Opened by Professor G. Elliot Smith, *M.A., M.D., F.R.S.*

The importance of recent acquisitions to our knowledge of comparative anatomy, embryology, and palæontology is the justification for reopening the discussion of this much-discussed problem.

My excuse for venturing upon the task of dealing with a subject that calls for an intimate acquaintance with a wide range of biological investigation, to which I cannot pretend to lay claim, is the fact that in all previous discussions the consideration of the influence exerted by the evolution of the brain in making

mammals what they are, as well as in supplying evidence to show whence they came, has been wholly ignored.

Evidence of teeth (Wilson and Hill) and fœtal membranes (Hill) clearly demonstrate that Marsupials are a degenerate stock sprung from a diphyodont, placental ancestry. The evidence of the early stages of development, such as the mode of development of the blastocyst and the presence of a shell-membrane (Hill), and the arrangement of the hippocampal formation and cerebral commissures and many other structural features, indicate that in most respects the Marsupials have retained, in far greater measure than the Eutheria, the features distinctive of the common ancestor of both groups. While recognising that all living Marsupials are specialised in greater or less degree so that no one of them could be looked upon as ancestral to the Eutheria, it must be admitted that the more highly specialised Eutheria in the course of their phylogeny must have passed through a stage not very different from that represented by the modern *Perameles*. If we are justified in applying the term 'Metatherian' to the hypothetical diphyodont, generalised-limbed, diminutive creature from which *Perameles* must have been derived, then we must recognise a Metatherian stage in the ancestry of the Eutheria. The similarity of structure in many of the more generalised Insectivora and Edentata, on the one hand, and the Polyprotodont Marsupials on the other, is so close, and the fact that structural modifications (especially in the brain) that are begun in the Marsupials are carried a stage further in the Eutheria can be explained only by admitting (*a*) the intimacy of the bond of kinship that links them, and (*b*) in recognising the ancestral Metatherian as a member of the Eutherian phylum.

The early zoologists included the Monotremes amongst the Mammalia because they had a hairy coat and mammary glands. Further research has completed the demonstration of their kinship to other mammals and established the monophyletic derivation of the whole mammalian group. Not only is the skin and its hairy and glandular epithelium typically mammalian, but also the alimentary canal and liver, the diaphragm, the auditory ossicles and their mode of development and the organ of Jacobson. In the brain the complex specialisation of the hippocampal formation and its curious fascia dentata, so peculiarly distinctive of the Mammalia, is carried to a degree of differentiation at least as great as in other mammals; the characteristically mammalian neopallium is present and emits a system of projection fibres forming both pyramidal and cerebro-pontine groups as in other mammals.

Hill has recently shown that the early phases of development in the Marsupials are a secondary modification of those through which the Monotremes and their reptilian ancestors pass in ontogeny. In many other features, such as the shoulder girdle (Broom), laryngeal cartilages (Weber), and azygos veins (Beddard), the ontogenetic development of certain Marsupials recapitulates that of the Monotremes.

In *Perameles*, the Marsupial which retains the allantoic placenta of its ancestors and many other primitive features in its structures, we find the plumpness of the cephalic end of the hippocampal arc, which is lost to a greater extent in most other Marsupials and all Eutheria, but is reminiscent of the Prototherian condition.

The living Monotremes are separated by a very wide gap from the closely related Meta- and Eutheria. At a very early stage in the history of the Mammalia, soon after the acquisition of skin, hair, milk-glands, and the appearance of the typical hippocampus and neopallium, the Prototheria divided into two phyla, one of which retained its generalised features and the other specialised. From the former the common Metatherian ancestors of all the Metatheria and Eutheria sprang by gradual transformation: from the latter the highly differentiated structure of the living Monotremes was derived, creatures which display a very high degree of specialisation, in association with the fixation of certain extremely primitive phases of mammalian structure, to display to us what the primitive mammal just emerged from the reptilian stage was like.

All mammals were sprung from an oviparous Prototherian stock, vastly different from the living Monotremata, but still deserving the name Prototheria. There is an overwhelming mass of evidence of varied nature, anatomical, embryological, and palæontological, to prove that the mammalian phylum sprang from the Reptilia.

From time to time one investigator after another has fixed his attention on some detail in mammalian anatomy, and magnified it into an insuperable obstruction against the possibility of a reptilian derivation. The occipital condyles, the mesenteric vessels, the epiglottis, the mode of development of the heart, the nature of the skin and its sense organs, the auditory ossicles, and the early phases of the Eutherian blastocyst; these features, among others, have been used time after time as arguments for an Amphibian, in opposition to a Reptilian, ancestry for mammals.

The argument from the blastocyst has been utterly demolished by Professor J. P. Hill's recently published researches on the early embryology of *Dasyurus*; or, perhaps, it would be more accurate to say he has turned the tables upon those who have been insisting upon the supreme importance of embryological evidence by demonstrating the thoroughly sauropsidan derivation of the mammalian mode of blastocyst-formation.

Palæontologists—Osborn, Broom, and others—have shown how the bicondylar arrangement of the Amphibian occipital bone has persisted in many extinct reptiles and especially in that particular group of Theriodonts which present such a remarkable series of mammalian resemblances in their skeletons.

The comparative anatomy of the brain in various Vertebrate groups affords positive evidence that in the course of its evolution the cerebral cortex passed through a particular stage, which is not met with except in the Sauropsida. The process of differentiation of the mammalian hippocampal formation becomes intelligible only when the preparatory stages represented in the Reptilian brain are known. The Amphibian brain, on the other hand, so far from helping us to understand the mammalian cortex, is a source of confusion, because its cortical formation has become so specialised, or perhaps so degenerate, in comparison with its forerunner, as witnessed in the Dipnoi, or its successor, as witnessed in the Reptilia, that we must regard it as being off the path that led to the Mammalia.

In spite of the certainty that the mammalian brain passed through a reptilian stage in its phylogeny, the brain of no living reptile fulfils the conditions required in the actual ancestor of the Protomammalia. Each is diversely specialised in some way. The brain of *Sphenodon* represents a curious blending of primitive features with Lacertilian and Chelonian characteristics; but it inclines too decidedly to the Lacertilian phylum to afford a type of the ancestral reptilian brain.

Here, however, the palæontologists come to our aid, not in giving us any further information regarding the brain, but in indicating an extinct group of early reptiles, which had not undergone those specialisations that gave birth to to Rhyncocephalia, Lacertilia, Chelonia, &c., but retained a more generalised structure, and at the same time have developed traits definitely foreshadowing the Mammalia.

The general nature of this evidence as collected and set forth by Owen, Seeley, Osborn, and others has long been known; but the recent work of Broom and D. M. S. Watson (of Manchester) has given us a much more intimate acquaintance with the structure of the Triassic Cynodontia (or the large group including it, which Broom has called 'Therapsida') of South Africa; and it is now difficult to resist accepting the obvious significance of their observations. The Therapsida present a curious blend of primitive reptilian and primitive mammalian features, many characters of the skull of the Rhyncocephalia, of the Polyprotodont Marsupials, and of the Insectivora being reproduced with surprising exactitude; and in the limbs Prototherian peculiarities are often closely reproduced, or rather foreshadowed.

Comparative anatomy and embryology point to a primitive reptilian as the parent of the Prototherian phylum. It is unnecessary for us to discuss a hypothetical group in this search for mammalian origins. For even if we have not found the actual ancestor, the group of extinct Cynodonts provides us with so many forms presenting mammalian characters of skull and teeth, and limbs and trunk, that it is no longer possible to refuse to recognise them as the representatives of the order to which the ancestor of the Prototheria belonged.

The impossibility of deriving either Reptiles or Mammals from the true Amphibia.

In the course of its evolution from the Dipnoan stage the Amphibian brain

has in great measure lost precisely those features which are essential if it is to develop into the reptilian or mammalian condition.

Perhaps both Amphibia and Reptilia derived directly from Stegocephalia.

Recent research, especially in regard to fossils from the Permian of Texas, has brought to light Stegocephalians so closely resembling reptiles, and reptilian remains so Stegocephalian, that there can no longer be any question of the genetic relationship between the two groups.

Although many biologists are apt to lay emphasis upon the aberrant and specialised features of the Dipnoi, and look to the Crossopterygii for the derivation of the Stegocephalia, the features of the brain in the lung fishes so definitely foreshadow the conditions seen in the Reptilia that it is difficult to believe that the Dipnoi can be far removed from the direct path leading to the Amniota.

At the same time, the Dipnoan brain, in its general plan, though not in its histological detail of its cortex, is essentially Amphibian. This fact, taken in conjunction with the palæontological evidence, suggests that the Stegocephalian brain may have bridged the gap between those of the Dipnoi and the Reptilia.

It is unfortunate that we know nothing of the form of the brain in the Cynodonts, for the transformation of its cortex must have played a leading part in the evolution of the Mammalia.

Broom tells us that the South African Theriodonts, from which mammals were derived, became distinguished from their American allies by the development of powerful limbs, and that 'it was the lengthened limb that gave the start to the mammals.' 'When the Therapsidan took to walking with its feet underneath and its body off the ground it first became possible for it to become a warm-blooded animal. All the characters that distinguish a mammal from a reptile are the result of increased activity—the soft flexible skin with hair, the more freely movable jaws, the perfect four-chambered heart, and the warm blood.'

Broom confesses his inability to explain how this fateful lengthening of the limbs was caused.

The realisation of the changes which took place in the brain in the transition from reptiles to mammals seems to suggest an explanation of this and the acquisition of many other mammalian features.

The development of a definite neopallium (the cerebral cortex *sensu stricto*), the lengthening of the limbs, the increased activity, the freeing of the skin of its mail-like coat of scales and conversion of it into a highly developed tactile organ—all these events occurred at about the same time, and had a reciprocal influence one upon the other.

By the time the Reptilia were evolved the cerebral hemisphere had reached a stage of development which opened up vast possibilities of new developments. Though the cerebral cortex was still mainly olfactory in function, tactile, gustatory, visual, and perhaps auditory impulses were able to make their entry into it; but it exercised little *direct* control over the movements of the body, which were still regulated by the midbrain.

The possession of this potential receptive organ in the cortex for receiving tactile impressions and bringing them into relation with impressions from the other sense-organs gave an added importance to the tactile sensibility of the ridges of skin that intervened between the scales of the Hypotherian. Moreover, more precise movements of the limbs became possible, because more exact information was being provided of the positions of the limbs by these tactile impressions.

The enhanced importance of the skin as a tactile organ led to the atrophy of the scales, perhaps by a process of natural selection; and the greater perfection of the tactile sensibility of the skin on the one hand, and of its receiving and recording apparatus in the cortex on the other, reacted mutually one upon the other and gave birth to the neopallium. It is not without significance that from its earliest appearance the neopallium performed the function of regulating 'skilled' movements of the whole body, *i.e.*, such actions as are possible only when there is a highly developed tactile information-bureau to render nicely adjusted movements possible. Moreover, quickness and increased activity are made possible by the neopallium, because it was put into direct connection *ab initio* with all the motor nuclei in the whole central nervous system by the

pyramidal tract (which developed *pari passu* with the evolution of the neopallium); and also with the cerebellum (by the simultaneous development of the pons), which enabled the creature to co-ordinate the muscular activities of its whole body to perform quick, accurately adjusted, and skilled movements. It is such developments as these that made the mammals what we know them to be, that give them their dominant position and their plasticity, or power of rapid adjustment to varying environment.

It is only when such skilled movements are possible that long limbs, capable of supporting the body, can become useful appendages. The fact that such limbs were making their appearance in the Therapsida in Triassic times is tangible evidence of the birth of the neopallium in these Promammals.

Professor ARTHUR KEITH, Dr. C. W. ANDREWS, F.R.S., and Dr. MARETT TIMS took part in the discussion.[1]

7. *Note on the Manus of a Young Indian Elephant.*

By Professor R. J. ANDERSON, *M.D.*

The trapezoid is placed between the scaphoid, trapezium, second metacarpal, and os magnum. The latter articulates with the second metacarpal and the third articulates with the fourth and fifth. The base of the latter looks upwards and outwards and backwards. The length of the trapezium is 6·5 cm.; the breadth 4·5 cm. from side to side. This is much more like a metacarpal bone than are the other bones of the carpus. The lower surface is convex from before back and from within out. It reaches about halfway down the shaft of the second metacarpal. The 'metacarpal' of the first digit has both a proximal and distal epiphysis. The proximal is 1·3 cm. thick and is quite separable, in the skeleton, so are the distal epiphyses of all the metacarpal bones. The thickness of the lower (distal) epiphyses of the first metacarpal is 1·5 cm. One of the reasons given for regarding the metacarpal of the thumb as such is the relation of the bone to the carpus. Those who hold, or held, that this bone is a first phalanx, point out the proximal epiphysis. In mammals other than man differences occur in the number and arrangement of the epiphyses, as was pointed out long ago. Graefenberg looks upon the trapezium as a metacarpal bone. Coalescence of the carpal bones with adjacent bones is met with, not only in Carnivora, Insectivora and others, and occasionally in man, but coalescence of the carpus and metacarpus occurs in man also. It is not easy to prove the permanent separation of an epiphysial element as a normal act. One cannot find sufficient evidence for regarding the proximal epiphysis as an epiphysis that properly belongs to the trapezium, but became joined to the next bone of the ray in the course of development.

The metatarsal bone of the first toe (ray) has a proximal epiphysis. It is difficult to say that a distal epiphysis is present. This is usually urged in favour of regarding the bone as a phalanx. The internal cuneiform is long and articulates with metas I and II.

Professor Hans Virchow found in an Indian elephant, eighteen years old, several terminal end-phalanges unossified. The middle finger and middle toe suffer more in this respect than the others, and the fingers less than the toes. Sesamoid bones are formed in connection with the metacarpal- and metatarsal-phalangeal articulations, two each for the three middle, one for metatarso-phalangea I and for metacarpo-phalangea I. The fifth pair for the metacarpo-phalangea V are united and look like the beginnings of a post-minimus digit.

The flexor Carpi radialis helps perhaps to maintain the arch, but the ligaments, tendons, and sesamoids are more efficient. The tarsal movements are slighter. The small radiale in the elephant and the large triquetrum contracts with the large radiale and small triquetrum of Primates. The large manus and their navicular are examples of vital readjustment.

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[1] See *Nature*, December 28, 1911.

8. *Some Points in Manus and Pes of Primates.*
By Professor R. J. ANDERSON, *M.D.*

The development of certain fingers and toes in animal groups is now regarded as the ultimate result of efforts to respond to changes of environment. Not only in the more conspicuous examples of reduction in the number of the phalanges, but even in man, there is evidence of a polydactyl ancestry. The modifications of the limbs in Primates in order to meet the exigencies of life are illustrations of the possibilities of modifying what some regard as fixed types. The modifications may rise here as in other groups from the encouragement given limb elements to develop at the expense of their neighbours. The fourth finger and the fourth toe of lemurs are longer than their neighbours, not merely in their collective length but in the length of their constituent joints. The first metatarsal is longer in the foot than the remaining ones; in the hand the first metacarpal is not so long as the others. Cheiromys and Galeopithecus present special modifications. Those of the latter are outside the present note. The metatarsals of the fourth and fifth toes in the ruffed lemur are nearly equal. The length of foot in Pithecia is 11 cm., the length of hand is 7·5 cm. The calcaneus is much longer than broad in Cercopithecus, less so in Hylobates Mulleri. The second metatarsal is longest. There is a cartilaginous development, apparently, in the calcaneo-scaphoid ligament and an os peronei is present. The navicular is in position not unlike the scaphoid of the hand. The intermedium which is commonly supposed to be united to the tibiale to form the astragalus may not be the equivalent of the lunar of the hand, which may really be represented by the posterior or *outer* part of the astragalus or the os trigonum (as seen in man). The navicular commonly regarded as a centrale may be the equivalent of the scaphoid in the hand, according to W. Krause. Then the astragalus could be regarded as a lunar, and the astragalo-scaphoid of emys and the crocodile, and, as found, on one occasion, in man, as equivalent to the scapho-lunar which is found in carnivora and others. The breadth of the hand in Hylobates, across the base of the metacarpals is 1·8 cm., and across the distal ends 2·4 cm. The like measurements in the foot give 2·2 cm. in front and 2·4 cm. behind. In man the varieties in the carpus and tarsus are in part due to causes or factors that operate in other animals, as well as to factors that are called into play in attempts to imitate. Reduction of the number by coalescence, or increase of the number by the formation of new ossicles, may take place in both carpus and tarsus.

The importance of the study of varieties of these is clear from a practical aspect, as a variety may be taken for a fracture in carpus and tarsus. A separated epiphysis may resemble a fracture, so may a sesamoid. It is interesting to know that a very large number of varieties have been met with in the carpus in man. It would be safe to say that man is the only animal in which so many (thirty) varieties in the ossicles of the wrist occur. The number would be much larger if cases of coalescence and sesamoids were added. It seems almost certain that the power to imitate has led to the occurrence of bones in the wrist that have never been found in other animals. The same may be said of the bones of the tarsus, but there are not by any means so many as one might expect where the degree of movement is curtailed and the power of imitation limited. Tarsus varieties may exceed twenty. Coalescence of the talus and scaphoid is parallel to the scapho-lunar arrangement in many animals; I have found the former in man. It happens, indeed, that several variations are known. The os trigonum tarsi, which is oftener in adult men than in adult women, was considered by Hyrtl to be the broken off trochlear process of the talus. V. Bardeleben homologised the bone with the os lunatum of the hand.[1] The origin is due to certain mechanical factors that come into operation. The os trigonum is originally a skeletal part equivalent to the intermedium antebrachii (os triangulare). The size is 35 to 20 mm. by 10 to 15 mm. vertical. It lies behind the talus and articulates with the calcaneum by cartilage, fibrous tissue, or a joint; it may be connected with the talus. If an articulation exists the joint communicates with the talo-calcaneal. There are two parts of the posterior surface of talus, the

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[1] Professor Dwight has figured and described (*Anat. Anzeiger*) a secondary calcaneum and a secondary cuboid. He had discovered the latter by Röntgen rays skiagraph before cutting down.

propria and the trigonica. Sometimes this bone is divided into a posterior tibial and an anterior fibular piece; if the division be due to fracture it is hard to tell by Rontgen rays the difference. It may be an epiphysis, a separated process or a migrant os trigonum. Putting to one side the statistics of fracture given by Lilienfeld (quoted by E. Biborgeil in 'Zeitschrift fur Aerztliche Fortibildungen'), it may be said that pathological deposits may occur owing to degeneration; but the os trigonum should show surface for articulation.

An *os tibiale externum* is a sesamoid bone belonging mainly to the tibialis posticus. It is more often found in women than men (unlike the os trigonum). It may, if large, be in relation with the talus, and navicular, or (2), if smaller, with navicular alone, or (3) it may be imbedded in soft parts and be in relation with neither. It is sometimes like exostosis of navicular (Pfitzner). It may be fused to navicular, and the talus may slide over its cartilage or membrane-covered surface.

Gruber saw the tuberosity drawn out in 10 per cent. of the examples. Jaboulay believed that the os tibiale externum was an epiphysis of navicular and joined to it by cartilage. Waldeyer figures four cases of os tibiale externum which are found near the tuberosity or in place of it. V. Bardeleben says this bone is a sixth toe-ray to be homologised with the tibiale of Gegenbaur. Waldeyer is of opinion that the name has been used in different senses by different authors. Three of these were typical skeletal parts. Some examples are to be regarded as ossification of tendons or ligament. The recognition of the bone is of the greatest importance by palpation or Röntgen rays. The sesamium peroneum lies in the postero-lateral end of the cuboid bone (oblique eminence). It is ossified cartilage and is better seen in the lower apes, and oftener, than in man. It is sometimes seen well in the chimpanzee. It is sometimes imperfect or degenerate. An os intermedium tarsi is also found in the dorsal side of the first interosseus space. It is apt to be pointed and cartilaginous and articulates with cuneiform I, and metas I and II. Gruber found this bone anchylosed to one of the adjacent bones. The *os vesalianum* is found rarely, and between the fifth metatarsal and cuboid and articulating with these. It may have an independent ossific centre and afterwards unite to metatarsal V, or it may coalesce before bone is laid down. This ossicle may be confused with a fracture fragment. Dwight found a secondary cuboid and a secondary calcaneum. He uses the Röntgen rays to examine wrists and ankles after the superficial parts are removed.

The possibilities of these ossicles occurring in the foot prove, for some, that the lower extremity has still in the course of its development the elements of change, and, though the Caucasian's foot is specialised, yet retrogressive metamorphoses may be possible. It is certainly true that just as the left hand is susceptible of training, the training of this limb and that of the lower limbs by means of evolutions may be attended with the greatest advantage to man.

WEDNESDAY, SEPTEMBER 6.

The following Papers were read:—

1. *On the Renal Organs and some other Features of the Internal Anatomy of Squilla. By* W. N. F. Woodland.

In view of the isolated position of the Stomatopoda (the group without doubt having arisen from the base of the Malacostracan stem), the large size and high development of the principal genus Squilla, and the statement made by Kowalevsky that the renal organ is a maxillary gland, it is remarkable that this structure has, up to the present, attracted so little attention. One might have anticipated that, the researches of Marchal, Grobben, Kingsley, and others having demonstrated the high degree of complexity attained by the antennary gland in the higher Malacostraca, some curiosity might have been felt respecting the development of the other pair of renal organs found in Malacostraca almost as

large and in many respects as well developed as the larger Decapoda. However, apart from the few bare statements made by Kowalevsky, the large complex maxillary gland of Squilla has remained undescribed. On opening the thoracic cavity of Squilla, the maxillary glands appear as a pair of large massive organs, with slender ducts running vertically down to the bases of the second maxillæ, opening on papillæ, as surmised by Calman. These maxillary glands, in fact, strongly resemble at first sight a pair of mandibular adductor muscles, and possibly they have been mistaken for such by previous workers. The description of the structure of these glands supplied in the present paper has been derived from a careful examination of two complete series of transverse and one complete series of longitudinal sections through adult specimens of *Squilla desmarestii*; stages in the early development have also been ascertained from transverse and longitudinal series of sections of Erichthus larvæ of different sizes. In an Erichthus larva measuring a little over 2 mm. in length the gland merely consists of a short narrow tube opening externally on the maxilla and ending internally in a slight dilatation—the end sac. Excepting those composing the wall of the end sac, all the cells of this young gland show a striated border and were doubtless functional. In an Erichthus larva measuring 12 mm. in total length the gland has altered in shape, having become divided into two thin-walled bladder-like compartments (the kidney proper and the end sac) lying side by side, closely apposed (the two walls only being separated by the narrow hæmocœle), and communicating by a small aperture situated at their posterior ends. In a slightly older Erichthus (14 mm.) the walls of all parts of the gland are seen to be undergoing invagination at numerous points, so as to form internal lamellar folds containing extensions of the hæmocœle. In the adult the large cavity of the gland has become almost completely broken up into a network of spaces owing to the further extension and branching of these internal invaginations, and since the two-layered septum dividing the kidney from the end sac has also given off these lamellar extensions on both sides, it is impossible to distinguish clearly between these two regions, the only distinction being that in the end sac the cavity is not so much invaded as in the kidney proper.

Among other features of the adult internal anatomy may be mentioned the presence of a well-developed Nauplius eye, rectal glands (possibly also rudimentary urinary tubules similar to those of Amphipods) and a very short proctodæum. Orlandi's correction of the old and oft-repeated statement concerning the numerous paired openings of the 'liver' into the gut is valid, but he errs in supposing that the single pair of 'hepatic' ducts (described and figured in the larva by F. Muller in 1863) are narrow and open dorsally into the pylorus; on the contrary, the apertures are wide and open laterally. Orlandi's figure (reproduction of a photograph) is quite misleading.

2. *The Hypostome and Antenna in a reconstructed Trilobite* (Calymene). *By* MALCOLM LAURIE, *B.A.*, *D.Sc.*, *F.L.S.*

In this attempt at reconstructing a Trilobite by Professor Sollas' method, the grinding instrument used was of comparatively simple construction. It consists of a central portion in which is a sliding tube pushed forward by a micrometer screw, just as in a Cathcart microtome. This central block is supported on ivory points placed at the ends of three radial arms six inches in length. Grinding is done on a sheet of plate glass with fine emery and the fossil is brought each time to the exact level of the three ivory points. For photographing, the whole machine is placed in a stand rigidly connected with the camera, and, its position being determined by the three points, it comes automatically into focus.

Two points of interest have as yet come out of the work, one relating to the position and structure of the mouth, the other to what seems an antennary structure. The mouth has always been considered as opening behind the hypostome. This reconstruction shows the hypostome to be, roughly, pentagonal in shape, with a strong, almost straight, anterior margin. The long oblique posterior margins are comparatively thin and reflexed for the posterior half, as though for the attachment of muscles. The short lateral margins have articular surfaces half-way down by which the hypostome articulates, with the internal surface of the carapace just at the margin of the glabella. Owing to the shortness

of the lateral margins this articulation is about a quarter of the length of the hypostome from the front. The hypostome has further a prominent central projection. The whole length of the hypostome is about half that of the carapace.

The front margin of the carapace turns down and then turns in on itself, This turned-in portion is articulated to the turned-down part so as to be capable of free movement, and the turned-down part is marked by a suture which was probably also capable of movement. The size and formation of the hypostome render it extremely improbable that the mouth opened behind it. Apparently the arrangement was that the hypostome, turning on its articulation, projected its anterior margin ventrally, while the inturned margin of the carapace also projected ventrally, the two forming lower and upper lips respectively to the mouth.

In a line between the lateral margin of the glabella and the eyes there has appeared a long conical structure divided into joints by strong annular thickenings and also furnished with finer annulations. This structure is more than two-thirds the length of the carapace and has a breadth at its posterior end of one-eighth of its length. I have been unable to find it on the other side of the specimen, but the specimen was cut just along that line by a lapidary's wheel, which may have destroyed it. The posterior end lies in the horizon of the second free segment, but as the ventral membranous body-wall is not distinct, it is impossible to say whether it is precisely *in situ* or not. The structure certainly resembles an antenna more than anything else and must have been joined to the body-wall behind the hypostome, as otherwise it could not have been withdrawn when the animal rolled itself up. The antennæ described by Beecher in Triarthrus also arise pretty far back. This has given rise to some confusion, owing to the popular idea that an antenna must arise from the head. Morphologically that is true, but post-oral appendages may assume an antennary function and structure, as in Phrynus and Thelyphonus, and we probably have such a case in these Trilobites. Any discussion of the probable morphological bearing of the two points I have described here is better postponed till our knowledge is a little further advanced.

I hope to communicate a fuller account of these and other points to the Royal Society of Edinburgh during the coming session.

3. *The Crop of the Leech.*

By Professor MARCUS HARTOG, *M.A.*, *D.Sc.*

As seen but never fully studied by the older observers, but apparently forgotten latterly, the crop of the leech is divided into eleven chambers; these are separated by distinct simple septa passing inwards from the obvious external constrictions, and perforated by a central hole, circular under ordinary conditions, but vertically elongated in distension, having the form of an inverted isosceles triangle with rounded angles. The septum shows a beautiful puckering at the free edge and capillaries loop over it, and contains a circular sphincter, but no divaricator fibres; it is bounded laterally by the posterior dorsiventral muscles, which run in the constrictions. Similarly the anterior dorsiventral muscles run in the less marked constrictions across the middle of each chamber. Successive truncheons of the hardened distended leech are necessary to display the structure, which is inconspicuous in ordinary dissection, and which is not easily recognisable in the usual transverse thin section.

4. *Lantern Demonstration illustrating the Development of the Starfish* Solaster endeca (*Forbes*). *By* JAMES F. GEMMILL, *M.A.*, *M.D.*, *D.Sc.*

Egg yolky; segmentation total, equal; blastula formation much as in *Cribrella;* gastrula by invagination; a free swimming 'larval' stage without mouth, and with blastopore closed; larva with three arms and a sucker; metamorphosis occurring in such a way that, while in point of external form the left side of the larva becomes the oral surface of the starfish, in reality the epiderm of the oral surface is partly derived from that of the preoral lobe. The aboral surface of

the starfish has similar relations with the right and the posterior aspects of the larva.* Definite sequence in formation of hydrocele lobes. Mode of numbering the lobes. Archenteron ultimately divides into anterior, middle, and posterior chambers. The middle chamber gives rise to the gut, the development of which histologically and otherwise may be said to be post-dated. The posterior chamber gives rise to the hypogastric and pharyngeal cœloms, to all but segment IX/I of the external oral circular sinus, to the genital pocket and cavity of aboral circular sinus. The anterior chamber gives rise to the rest of the typical series of internal cavities. As regards skeleton, two terminals appear at the tip of each arm rudiment, while the first aboral plates are numerous and distributed without reference to radii and interradii. Anus develops in interradius V/VI. A larval nervous system and a statolith-like body. Early growth and habits of the young *Solaster*. Methods employed to rear them at the Millport Marine Station.

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5. *Remarks on some of the Boring Mollusca.*
By W. T. Elliott, *F.Z.S.*, *and* B. Lindsay.

A theory has been put forward, at various times and in various forms, that the work of marine boring organisms is performed by means of an acid secretion.

In the saliva of predatory shell-piercing Gasteropods an acid really exists. This, in the Sting-winkle, has been studied for the sake of comparison, but the presence of acid secretion in the head of a Gasteropod affords no presumption that it may occur in the foot of a mollusc of another class.

Observations on the boring marine organisms of the shore at St. Andrews confirm the statement of Professor McIntosh that their method of boring is mechanical and not chemical. No acid secretion was detected at any time.

Zirphæa (Pholas) *crispata* and *Saxicava rugosa* both work by means of vacuum-suction, supplemented by scraping movements of the shell, which in the former are continuous and purposeful during the time of boring. Vacuum-suction is created by co-operation between the mantle and the foot. The part played by the folds of the mantle is indicated by the structure of the shell in *Zirphæa*.

The common limpet, when on sandstone, works for itself a shallow depression in a similar way by suction assisted by shell-scraping movements, but the latter are not purposeful. It does not succeed in making any depression in harder rocks.

The boring molluscs are not singular among boring organisms in working by mechanical means. The annelid *Polydora ciliata*, very common at St. Andrews, also does so, and is typical of boring annelids in its method of procedure. It wears away the substance in which it works by the muscular action of a coil of its body; often fixing its head so as to use it for a fulcrum, and sometimes using the tail in a similar way, by means of the terminal suction-cup.

The boring of these and other organisms probably has an important bearing on coast erosion. At St. Andrews the boring-grounds exist in close proximity to instances of sea encroachment, and the same fact may be observed near Blackpool in Lancashire and in the chalk cliffs near Brighton.

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6. *Discussion on Wallace's Line. Opened by* C. Tate Regan, *M.A.*

The distinguished naturalist, Alfred Russel Wallace, spent several years (1854-62) in the Malay Archipelago, making zoological collections and studying the islands and their inhabitants; he came to the conclusion that the islands should be grouped in two main divisions: an Indo-Malayan, comprising Borneo, Sumatra, Java, with Bali and the Philippines, and an Austro-Malayan, including New Guinea, the Moluccas, Celebes and the islands from Lombok to Timor.

The line separating these two divisions has long been known as 'Wallace's Line,' and for many years was generally accepted as the boundary between the Oriental and Australian Zoogeographical Regions. This view has lately lost ground considerably, and some zoologists now include Celebes and the Timor

Group in the Oriental Region, substituting 'Weber's Line'[1] for 'Wallace's Line' as the zoological boundary between Asia and Australia. In the opinion of some authorities Wallace's Line has scarcely any importance; thus a contributor to a recent edition of the 'Encyclopædia Britannica' writes of 'the now exploded Wallace's Line,' and Professor Max Weber calls it 'this unfortunate line'! He has written at considerable length on the origin of the fresh-water fish fauna of the Malay Archipelago,[2] and holds that that of Celebes has no Australian, but a highly impoverished Indian character, and that there is no sharp boundary between Bali and Lombok, the southern impoverishment beginning in Java and becoming more marked in Bali.

I think that to illustrate the geographical distribution of fresh-water fishes it is necessary to make a primary division between the Australian Region, including the islands to the east of Wallace's Line, and the rest of the world. In the Australian Region we have two archaic types (*Ceratodus*, *Scleropages*), but all the other fresh-water fishes belong to marine families or genera. Peculiar genera of sea-perchase (*Serranidæ*, *Kuhliidæ*), sand-smelts (*Atherinidæ*), gobies (*Gobiidæ*), &c., form an important element in the fresh-water fish fauna, but there are no peculiar fresh water families.

In the rest of the world, the fresh-water fish fauna consists mainly of families which are confined to fresh water, and which we have every reason to believe have evolved their genera and species in fresh water; such fishes are of the highest importance of evidence of former land connections or of ancient lines of severance.

The dominant group of fresh-water fishes is the order *Ostariophysi*, including the cat-fishes, characins, electric eels, carps, loaches, &c.—not fewer than three thousand species, all true fresh-water fishes except the cat fishes of the groups *Ariinæ* and *Plotosidæ*, which are (secondarily) marine, and which alone cross Wallace's Line eastwards.

In Borneo[3] the true fresh-water fishes are mostly *Ostariophysi*. Of this order there are approximately—

120 species of *Cyprinidæ*
20 ,, ,, *Cobitidæ*
15 ,, ,, *Homalopteridæ*
80 ,, ,, *Siluridæ* (excluding *Ariinæ*)
10 ,, ,, *Clariidæ*
1 ,, ,, *Chacidæ*

None of these families is represented in Celebes, neither are the *Nandidæ* (five species in Borneo) nor the *Mastacembelidæ* (seven species in Borneo). What then are the fresh-water fishes which give Celebes its Indian character? They are, first of all, Labyrinthic fishes, found in the Ethiopian and Oriental Regions, and represented in Borneo by—

1 species of *Luciocephalidæ*
12 ,, ,, *Anabantidæ*
20 ,, ,, *Ophiocephalidæ*

Two of the commonest Indian species, *Anabas scandens* and *Ophiocephalus striatus*, not only cross Wallace's Line, but Weber's Line, occurring in Celebes, the islands from Lombok to Timor, Amboina, and Halmahera. It is almost inconceivable that these islands can have been connected with each other and with Asia during the life-time of these two species, yet Professor Max Weber contends that they have not been introduced, as he found them in places where the population was not sufficiently civilised to have introduced them. This contention loses its force when we remember that the Labyrinthic fishes are remarkable for the time they can live out of the water and for their habit of migrating overland from one pond or stream to another, and that these two species are greatly appreciated as food by the Malays and the Chinese.

Two Indian Symbranchoid eels, *Monopterus javanensis* and *Symbranchus*

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[1] Pelseneer, *Bull. de l'Acad. roy. de Belgique*, 1904, p. 1001.
[2] *Zool. Ergebn. Reis. Ned. Ind.*, iii, 1894.
[3] Cf. Popta, *Notes Leyden Mus.*, xxvii., 1906.

bengalensis, are known from Celebes. These are brackish-water fishes, and the distribution of the species of Symbranchus leaves little doubt that they sometimes descend to the sea; indeed *S. bengalensis* has been recorded from Western Australia. *Monopterus javanensis* parallels *Anabas scandens* in its wide distribution, its importance as a food fish, and its vitality.

Two endemic Cyprinodonts are found in Celebes, one belonging to the Asiatic genus *Haplochilus*, the other to a peculiar but related genus. There can be little doubt that these originally reached Celebes by sea. Many fishes of this family are marine, and although the Indian species are usually reckoned as fresh-water, Day tells us that they are nearly always found in estuaries or not far from the sea.

In my opinion, the Indian element in the fresh-water fish fauna of Celebes consists of (1) introduced species and (2) species which have journeyed by sea; the same is true of the islands from Lombok to Timor, which have only a *Haplochilus* and the two Labyrinthic fishes, *Anabas scandens* and *Ophiocephalus striatus*, already disposed of. Bali is a small island, and its fresh-water fish fauna is not too well known, but is doubtless poor in proportion to its size; nevertheless, we know that it is inhabited by a siluroid of the genus *Clarias*, two species of Cyprinids, and an Anabantid in addition to *Anabas scandens*. Java has a fresh-water fish fauna extremely similar to that of Sumatra and, considering its smaller size, is probably as rich in species; it is rather straining a point to call the absence of *Luciocephalus pulcher*, the only species of its family, an impoverishment of the Indian fauna, and still more so to apply this term to the absence from Java of the Sumatran and Bornean *Scleropages formosus*, since the only other species of *Scleropages* inhabits Queensland.

For fresh-water fishes Wallace's Line is neither 'exploded' nor 'unfortunate,' but of fundamental importance. The rich and varied fish fauna of Java, Sumatra, and Borneo, with most of the genera and many of the species identical with those of the mainland of Asia, indicates clearly that these islands formed part of the continent quite recently. The absence from Celebes of true fresh-water fishes shows that this island has not been connected with Asia during the Tertiary Period. The *Ostariophysi* are an ancient group, and probably most of the families were differentiated in Cretaceous times; Siluroids are known from Lower Eocene deposits in various parts of the world; the North American *Catostomidæ* are also known from the Lower Eocene; the Cyprinids and Loaches of the Oligocene and Miocene of Europe differ only specifically from their modern representatives, and this is true of the Cyprinoids and Siluroids of the shales and lignites of Sumatra, usually regarded as of Eocene age, but possibly Miocene. Professor Max Weber thinks that Celebes did not separate from Asia until it had received its mammals. It seems to me significant that the mammalian fauna of Celebes consists so largely of arboreal types, specially liable to accidental transmission, or of strong swimmers.

Celebes is an anomalous island, as Wallace well called it; belonging to the Australian Region, yet from its remoteness and its long isolation deficient in Australian types. During its long proximity to the Oriental Region it has acquired in one way or another a certain number of Indian forms which obscure its real affinity. The Timor Group seems to have had a somewhat similar history; its zoological distinctness from the Indo-Malay Islands is confirmed by the fresh-water fishes. It may therefore well be the case that Wallace's Line marks the severance of Australia from Asia at or before the commencement of the Tertiary Period.

SECTION E.—GEOGRAPHY.

PRESIDENT OF THE SECTION.—LIEUT.-COLONEL CLOSE, C.M.G., R.E.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

I PROPOSE to devote the first part of this address to an examination of the purpose and position of Geography, with special reference to its relations with other subjects. It will not be possible entirely to avoid controversial matters; but, if some of the questions touched on are controversial, this only means that these questions have a certain importance. I shall try to describe the facts of the case impartially.

In the second part I shall try to indicate briefly what the Government, as represented by the great Departments of State, is doing for Geography.

PART I. *The Position of Geography with reference to other Subjects.*

It is no secret that the geographical world is not unanimous about the meaning and object of Geography. The definitions suggested by such writers as Mr. Chisholm, Professor Davis, Professor Herbertson, Mr. Mackinder, or Dr. Mill are not in agreement. From time to time an attempt is made to formulate some statement which shall not commit the subscribers to anything very definite. But differences of opinion on the subject persist.

There are, of course, a great many ways of approaching the question. Let us, for example, examine the proceedings of such representative bodies as the British Association and the Royal Geographical Society, and of such assemblies as the International Geographical Congresses, and let us see if we can find out what is, as a fact, the scope of the subject as dealt with by these bodies. They are institutions which work in the full light of day, and they are too large to be dominated for any length of time by individuals. If we can find any working principle, any common term, amongst these societies, we shall have gone some way towards arriving at a solution of the problem.

A simple method of investigation is to discuss the character of the publications of these societies and of the lectures delivered before them. And I feel that I cannot do better than devote most of this brief analysis to the Royal Geographical Society and its admirably edited Journal. Here we are on safe ground. If an inhabitant of another planet wished to know what we understand by astronomy we could confidently refer him to the 'Monthly Notices' of the Royal Astronomical Society. If he were curious about the condition of geology, we should give him the volumes of the Geological Society. And, if he were so rash as to ask what are the objects of the modern mathematician, we should hand him the papers published by the London Mathematical Society. The 'Geographical Journal' occupies no lower a position with reference to Geography than do the other journals mentioned with reference to the sciences with which they deal.

In analysing the contributions to the Royal Geographical Society it is im-

portant to start with an honest classification. In the endeavour to be impartial I have chosen the classification which was adopted for the last International Geographical Congress, *i.e.*, that held at Geneva in 1908. This Congress was divided into fourteen sections. It will serve to clear the ground if we deal first with sections 12, 13, and 14; these are the Teaching of Geography, Historical Geography (which was mainly concerned with the history of travel and exploration), and Rules and Nomenclature. For the purpose of discovering what Geography is these three sections will not be of any assistance. Every subject has its educational side, its history, and its rules and nomenclature. The subject proper was, therefore, divided into eleven sections. The eleven sections are the following:—

1. Mathematical and Cartographical Geography.
2. General Physical Geography.
3. Vulcanology and Seismology.
4. Glaciers.
5. Hydrography (Potamography and Limnology).
6. Oceanography.
7. Meteorology and Climatology; Terrestrial Magnetism.
8. Biological Geography.
9. Anthropology and Ethnography.
10. Economic and Social Geography.
11. Explorations.

Before applying this classification to the work of the Geographical Society I wish to call attention to the extremely frank way in which vulcanology, seismology, meteorology, climatology, terrestrial magnetism, anthropology, and ethnography are included in Geography. The list in fact covers ground occupied by several Sections of the British Association.

I have investigated the work of the Geographical Society for the five complete years 1906 to 1910. The original contributions to the 'Geographical Journal' have been examined for that period, omitting from consideration contributions on the subjects of teaching, the history of exploration, and rules and nomenclature.

There are altogether 296 original papers which come under one or another of the eleven headings given above. Of these papers 171, or 57 per cent., deal with Explorations and Travels. There is a great drop to the next largest section, General Physical Geography, which accounts for thirty papers, or about 10 per cent. Adhering to the order of the Geneva Congress the complete list is as follows:—

Original Contributions to the Proceedings of the Royal Geographical Society during the five years 1906 to 1910.

	Subject.	Percentage.
1.	Mathematical and Cartographical Geography	3
2.	General Physical Geography	10
3.	Vulcanology and Seismology	5
4.	Glaciers	3
5.	Hydrography (Potamography and Limnology)	5
6.	Oceanography	3
7.	Meteorology and Climatology; Terrestrial Magnetism	3
8.	Biological Geography	1
9.	Anthropology and Ethnography	3
10.	Economic and Social Geography	7
11.	Explorations	57

The main conclusion is obvious enough. For the principal Geographical Society in the world, Geography is still mainly an affair of explorations and surveys; if to this item we add cartography we account for 60 per cent. of the activities of the Society.

There is another important deduction which is natural and unforced: the papers on vulcanology and seismology and on glaciers could have been read with perfect appropriateness before the Geological Society; those on meteorology and

climatology before the Meteorological Society; and those on anthropology and ethnography before the Anthropological Society. To make quite sure of this point I will cite a few titles of the papers read: 'The great Tarawera Volcanic Rift,' by J. M. Bell; 'Recent Earthquakes,' by R. D. Oldham; 'Glacial History of Western Europe,' by Professor T. G. Bonney; 'Climatic Features of the Pleistocene Ice-Age,' by Professor A. Penck; 'Rainfall of British East Africa,' by G. B. Williams; 'Geographical Distribution of Rainfall in the British Isles,' by Dr. H. R. Mill; 'Geographical Conditions affecting Population in the East Mediterranean Lands,' by D. G. Hogarth; 'Tribes of North-Western Se-Chuan,' by W. N. Fergusson.

This little list of typical subjects indicates clearly that there is a large group of contributions which would have found an appropriate home in the journals of the Geological, Meteorological, and Anthropological Societies; there is a possible corollary that, since men who make a life study of these subjects are best capable of dealing with them, the authors of the above type of paper who submit their work to the Geographical Society in so doing appeal rather to the public at large than to men of their own special sciences.

We may therefore sum up the results of this brief investigation into the work of the Royal Geographical Society by saying that 60 per cent. of it is concerned with exploration and mapping, and that some of the remainder could be dealt with appropriately by the learned societies concerned, but that the Geographical Society serves as a popularising medium. It also serves a useful purpose as a common meeting-ground for vulcanologists, seismologists, oceanographers, meteorologists, climatologists, anthropologists, and ethnographers.

Another line of investigation may be profitably pursued. Who are, by common consent, the leading geographers of the world? No doubt the explorers come first in popular estimation, such men (omitting British names) as Peary, Charcot, Sven Hedin. Then after this type would come the men of learning who stand out in any International Congress. These men stand out because they have, by their own exertions, increased the sum of human knowledge. Omitting for the moment the consideration of exploration and mapping, we find that in an international congress a large number of the most celebrated geographers are eminent as geologists. In such a gathering we can also pick out those who have advanced the sciences of meteorology or anthropology. Is there such a thing as an eminent geographer *per se*? There are those who say that, apart from explorers, the nearest approach to such a being is the compiler who popularises the results obtained by men working in definitely scientific branches of knowledge.

To revert to the ideas gathered from an international congress, let us suppose the position reversed. Let the functions of geology be supposed to be somewhat in dispute and those of geography perfectly definite, and further let us suppose that at an international meeting of geologists a large proportion of the men of real distinction were geographers. We may in this way get an idea of what geography looks like from the outside.

I think that at this point we may explain, in a preliminary way, the work of the Geographical societies, after the fashion of the 'Child's Guide to Knowledge':—

Question: What is Geography?

Answer: There is no generally accepted definition of Geography.

Question: Can we not form some idea of the scope of the subject by considering the work of the Royal Geographical Society?

Answer: Yes; 60 per cent. of this work deals with explorations, surveys, and mapping, and of the rest a considerable portion consists of matter which could be discussed appropriately before the Geological, Meteorological, and Anthropological Societies.

Question: What, then, leaving maps out of consideration, are the useful functions of a Geographical society?

Answer: A Geographical society serves to popularise the work of men who labour in certain fields of science, and such a society forms a very convenient meeting-ground for them.

Question: What is a geographer?

Answer: The term geographer is sometimes applied to explorers; sometimes to men who compile books derived mainly from the labours of

surveyors, geodesists, geologists, climatologists, ethnographers and others; climatology, or ethnography, hope to advance human knowledge?

Question: Can a geographer who has not made a special study of one or more of such subjects as geodesy, surveying, cartography, geology, climatology, or ethnography, hope to advance human knowledge?

Answer: He can do much to popularise these subjects, but he cannot hope to do original work.

Another way of attempting to ascertain the meaning and object of Geography is to study the character of the instruction given in the universities, and we may suppose that this can be fairly judged by the contents of standard text-books. Let us take, for example, the 'Traité de Géographie Physique' of M. E de Martonne, formerly Professor of Geography at the University of Lyons, now Professor at the Sorbonne. The work in question was published in 1909 and is divided into four main sections -Climate, Hydrography, Terrestrial Relief, and Biogeography.

The first sentence of the book is 'What is Geography?' Twenty-four pages are devoted to discussing this question, which the writer, with all his skill and learning, finds it difficult to answer definitely and convincingly. One receives the impression of the dexterous handling of a difficult question, and of a generally defensive attitude. In this book geography is said to depend on three principles. The principle of *extension*, the principle of *co-ordination*, and the principle of *causality* As an illustration of the meaning of the principle of extension, we are told that 'the botanist who studies the organs of a plant, its conditions of life, its position in classification, is not doing geographical work; but if he seeks to determine its area of extension, *il fait de la géographie botanique*. I believe that we have here reached a critical point. The claim is, that when, in the prosecution of a botanical study, a map is used to show the distribution of a plant, the use of such a map converts the study into a branch of geography. Well, it is a question of definition and convention, which cannot, I imagine, be settled except by the general agreement of all the sciences. We have to make up our minds whether a man who constructs a distributional map is doing 'geography.' One thing, I suppose, is not doubtful. When the map is made it will be better interpreted by a botanist than by a person ignorant of botany. In the same way the discussion of an ordinary geological map is best undertaken by a geologist, and so on. It would appear that geography, in the sense mentioned, is not so much a subject as a method of research.

It will be convenient here to say a few words about the relations between societies and schools of Geography and those important subjects geodesy and geology. In the palmy days of the Ordnance Survey, when Colonel A. R. Clarke was still at work, the headquarters of geodesy in England was doubtless at Southampton. But, curiously enough, there is not, and has never been, in the United Kingdom a society or body specially charged with the study of geodesy. Geodesy, in fact, has no regular home in these islands. But the Royal Geographical Society has done a good deal in the past few years to stimulate an interest in the subject, thereby fulfilling what I believe to be one of the Society's most useful functions, that of popularisation.

If, however, an authoritative opinion were required on any geodetic question, where could it be obtained? Well, I suppose there is no doubt that the headquarters of this branch of learning is the International Geodetic Association, but the scientific work itself is being largely carried out at the Geodetic Institute at Potsdam, by the Survey of India, by the Geodetic Section of the Service Géographique, by the U.S. Coast and Geodetic Survey, and by similar bodies. Geodesy, especially in its later developments, is a definitely scientific subject which demands much study and application. It is but slightly touched upon by the schools of Geography. Perhaps I may here point out that geodesy is by no means mainly concerned with the shape of the spheroid. The chief problems are now those of isostasy and local attraction generally, the real shape of the sea-surface, the continuity of the crust of the earth and changes of density therein.

The position in which Geography finds itself with regard to Geology can be clearly seen if reference is made to the new edition of the 'Encyclopædia Britannica.' In the eleventh volume of this work are two important articles. 'Geography,' by Dr. H. R. Mill, and 'Geology,' by Sir Archibald Geikie. In

the article on 'Geography' we find a description of geomorphology as that part of Geography which deals with terrestrial relief, and a remark is made that 'opinion still differs as to the extent to which the geographer's work should overlap that of the geologist.' In this article, however, most of the authorities quoted are geologists, and the author remarks that 'the geographers who have hitherto given most attention to the forms of the land have been trained as geologists.'

Turning to the article on 'Geology' we find an important section on 'Physiographical Geology,' which is described as dealing with the investigation of 'the origin and history of the present topographical features of the land.' Now this is the exact field claimed for geomorphology. It has been observed by others, notably by Professor de Martonne, that the interpretation of topographic forms has been most successfully undertaken by geologists, and he gives as an instance of this the good work done by the United States Geological Survey.

I do not know whether any geographer untrained as a geologist has contributed anything of value to geomorphology.

Another test which may be applied is the following: Let us imagine Geography to be non-existent and note what the effect would be. Suppose there were no such things as Government Geographical Services, or Schools of Geography at the Universities, or Geographical Societies. The first and most obvious result would be that most, if not all, of our apparatus of exploration and mapping would have disappeared. But as we are all in agreement as to the necessity of this branch of human effort, let us restore this to existence and examine the effect of the disappearance of the rest.

So far as concerns geodesy, we should still possess the International Geodetic Association, the Geodetic Institute at Potsdam, and the United States Geodetic Survey, and similar bodies. But we should have lost the means of popularising geodesy in the proceedings of Geographical Societies; and, as there would be now no geographical text-books, elementary geodesy would not find itself between the same covers as climatology and geomorphology.

As regards geomorphology, or physiographical geology, not very much difference would be noted. The geologists would still pursue this important subject; but here again their writings would perhaps appeal to a more expert and less popular audience; although it is not to be forgotten that many admirable introductions to the subject have been written by geologists.

Much the same might be said about meterology and climatology. There would be text-books devoted to these studies, but there might be a diminution of popular interest.

Such names as phyto-geography would disappear, but the study of botany (if we permit it the use of distributional maps) would not be affected. The loss to knowledge would be mainly that of getting to a certain extent out of touch with the public. The constitutions of the various learned bodies would remain the same and so would their functions. The constitution of the Royal Society, which has never recognised geography as a subject, would be totally unaffected.

If we thus study the relations between Geography and other subjects we are almost bound to arrive at the conclusion that Geography is not a unit of science in the sense in which geology, astronomy, or chemistry are units. If we inquire into the current teaching of Geography, and examine modern text-books, we find that most of the matter is derived directly from the workers in other fields of study. And if we inquire into the products of Geographical societies, it becomes evident that one of the most important functions fulfilled by these useful bodies is to popularise the work of geodesists, geologists, climatologists, and others, and to provide a common meeting-ground for them. If Geography had been able to include geology and the other sciences which deal with earth-knowledge, it would then, indeed, have been a master science. But things have worked out differently.

I shall very probably be told that, in laying some stress on the above-mentioned aspects of the subject, I have forgotten that the main purpose of Geography is the study of the earth as the home of man, or the study of man as affected by his environment, and that, however necessary it may be to begin with a foundation of geodesy, geology, and climatology, we must have as our main structure the investigation of the effect of these conditions on the races of man, on human history and human industry, on economics and politics.

It is obviously and abundantly true that no student of history, economics, or politics can disregard the effect of geographical environment. But it is not, as a fact, disregarded by writers on these subjects. The question is, to a large extent, whether we should annex these portions of their studies, group them and label them 'Geography.' Our right to do this will depend on the value of our own original investigations. We have the right to use the results obtained by others, provided that we add something valuable of our own.

Before this human aspect of geography—or, for that matter, any other aspect of the subject—is recognised by the world of science as an independent, indispensable, and definite branch of knowledge, it must prove its independence and value by original, definite, and, if possible, quantitative research.

PART II. *Geography and the Government Departments.*

Whatever definition of Geography is accepted we are all in agreement that the map is the essential foundation of the subject. I propose now to indicate very briefly how the British Government, as represented by the great Departments of State, is, in this respect, assisting the cause of Geography. The Departments which are interested in maps and surveys are the following: The Admiralty, the War Office, the Colonial Office, the India Office, the Board of Agriculture, and the Foreign Office.

The immense services rendered, not only to this country, but to the whole world, by the Hydrographic Department of the Admiralty, are known to all. But it would be somewhat rash for a soldier to talk about hydrographic surveys, so I will confine my remarks to surveys on land.

First it should be remarked that the British Government as a whole has for many years shown its interest in Geography, and has recognised the good work done by the Royal Geographical Society by contributing an annual sum of 500*l.* towards the funds of the Society. Next it should be noted that from time to time British Governments have contributed large sums of money towards Arctic and Antarctic exploration. The most recent examples of this very practical form of encouragement will be remembered by all; I mean the Government expenditure on Scott's first Antarctic Expedition and the handsome sum contributed towards the cost of Shackleton's great journey.

Turning now to the *War Office*, the first matter to which I would call attention is that nearly all the accurate topographical surveys of the Empire have been started by soldiers. This applies to the United Kingdom, Canada, Australia, South Africa, Tropical Africa, and last, but greatest of all, India. The accounts of the struggles of soldiers at the end of the eighteenth century to obtain sanction for what is now known as the Ordnance Survey form very interesting reading. In fact, all over the world it was military requirements which produced the topographical map; and it is still the War Offices of the world which control the execution of almost all geographically important surveys. During the last few years the largest block of work undertaken by the War Office has been the accurate survey of the Orange Free State, which has an area of about 52,000 square miles—nearly the size of England—and an adjacent reconnaissance survey in the Cape of Good Hope covering an area of a hundred thousand square miles. There has been some inevitable delay (due to causes which need not be gone into now) in the publication of the sheets of this survey, but the work is being pushed on. The survey of the Orange Free State is fully comparable with the admirable surveys carried out by the French Service Géographique de l'Armée in Algeria and Tunis. Some work has also been done in the Transvaal. Other surveys carried out in recent years under the direct control of the War Office are those of Mauritius, St. Helena, a portion of Sierra Leone, Malta, and Hong Kong. The most notable work which is now being carried out in *the Self-Governing Dominions* is the Militia Department Survey of Canada, with which excellent progress has been made.

The total area of the Crown Colonies and Protectorates, under the rule of the *Colonial Office*, amounts to about two million square miles. British African Protectorates form a large portion of this total, and I will indicate briefly what is being done to survey these tropical Protectorates. From the geographical point of view the brightest regions are East Africa, Uganda, and Southern Nigeria. In East Africa topographical surveys of the highlands and coast belt

are being pushed on by military parties as part of the local survey department. The area of exact work done amounts now to some 30,000 square miles. In Uganda a military party has recently completed a large block of country, and in this Protectorate thoroughly reliable maps of 32,000 square miles are now available. In Southern Nigeria a completely reorganised survey department is tackling in a thoroughly systematic fashion the difficult task of mapping a forest-clad country. We shall shortly see the results.

For the information of those who have not travelled in tropical Africa it should be remarked that surveying in such countries is attended by every sort of difficulty and discomfort, and too often by illness and serious discouragement. It is one thing to sit at home in a comfortable office and plan a scheme of survey, and quite another thing to carry it out on the spot. We do not, I am convinced, give enough honour and credit to those who actually get the work done in such trying circumstances Honest accurate survey work in the tropics puts a much greater strain on a man than exploratory sketching. To picture what the conditions are, imagine that you are to make a half-inch survey of the South of England; cover the whole country with dense forest; put mangrove swamps up all the estuaries; raise the temperature to that of a hot-house; introduce all manner of insects; fill the country with malaria, yellow fever, blackwater fever, and sleeping-sickness; let some of your staff be sick; then have a fight with the local treasury as to some necessary payment, and be as cheerful as you can. That is one side of the medal. On the other side there is the abiding interest which the surveyor feels in the country, the natives, and the work; the sense of duty done; and the satisfaction of opening up and mapping for the first time a portion of this world's surface.

There is no time to mention other surveys in Africa, and I will pass on to a very interesting part of the world, the Federated Malay States. In this prosperous country much excellent geographical work is being done by the combined survey department which was established under a Surveyor-General in the year 1907. The department is in good hands, and the commencement of a regular topographical series is being undertaken.

I wish it were possible to prophesy smooth things about Ceylon. From our special point of view the situation leaves much to be desired. There is not yet published a single topographical map, and the topographical surveys are progressing at a rate which, under favourable conditions, may result in the maps being completed in the year 1970.

In closing this inadequate review of the principal surveys which are being undertaken in the Crown Colonies and Protectorates, I should mention that the co-ordinating factor is the Colonial Survey Committee, which every year publishes a report which is presented to Parliament.

The *India Office* is of course concerned with that great department the Survey of India. The Indian Empire has an area of about 1,800,000 square miles, and as, under the arrangements approved in 1908, the standard scale of survey is to be one inch to one mile, the area of paper to be covered will be 1,800,000 square inches. Actually this is divided into about 6,700 sheets. The Survey of India has always been famous for its geodetic work and for its frontier surveys and methods. Its weak point used to be its map reproduction. This has been greatly improved. But personally I feel that if, for most military and popular purposes, a half-inch map is found suitable for England, as is undoubtedly the case, there is no reason why a half-inch map should not also be suitable for India. It is mainly a question of putting more information on the published map, and of engraving it and using finer means of reproduction. If this smaller scale were adopted all the information now presented could be shown, and the number of the sheets would be reduced from 6,700 to 1,675, a saving of 5,000 sheets. It is difficult to avoid the feeling that the Survey of India is overweighted with the present scheme. The scheme has, however, many merits. It will be impossible to carry it out unless the department is kept at full strength.

The *Board of Agriculture* is the Department which is charged with the administration of the Ordnance Survey. The Ordnance Survey spends some 200,000*l.* a year, and for that sum it furnishes the inhabitants of the United Kingdom with what are, without doubt, the finest and most complete series of large-scale maps which any country possesses. There is nothing in any important country

(such as France, Germany, Italy, Russia, or the United States) to compare with our complete and uniform series of sheets on the scale of $\frac{1}{2500}$. These sheets are sold at a nominal price and are in effect a free gift to landowners, agents, and all who deal with real property. They are also, of course, invaluable to county and borough engineers and surveyors. They really are a national asset which is not half enough appreciated. The whole conception of these large-scale plans has stood the test of time and is greatly to the honour of a former generation of officers.

Much might be said about the small-scale maps of the Ordnance Survey, which are now published in a very convenient form. As mentioned above, the latest small-scale Ordnance map is the new international map on the million scale. Some sheets of this map will shortly be published.

The *Foreign Office* is concerned with the surveys of the Anglo-Egyptian Sudan, which are at present mainly of an explanatory character. The taking over of the Province of Lado has recently thrown fresh work on the Sudan Survey Department. The Foreign Office, which administers Zanzibar, has recently given orders for the survey of the Island of Pemba, a dependency of Zanzibar, and this is being carried out by a small military party.

But the greatest service to Geography rendered by the Foreign Office in recent years was the encouragement given to the project of the International Map by the assembly of an international committee in November 1909. Sir Charles (now Lord) Hardinge presided at the opening session. There were delegates from Austria-Hungary, France, Germany, Great Britain, Canada and Australia, Italy, Russia, Spain, and the United States, and, as is known, the resolutions which were devised by the Committee were agreed to unanimously. After the conclusion of the work of the Committee the Government communicated the resolutions to all countries which had not been represented, and nearly all the replies which have been received are favourable. Maps in exact accordance with the resolutions are, it is understood, being produced by France, Hungary, Italy, Spain, the United States, and other countries, and so far as we are concerned, by the General Staff, the Ordnance Survey, and India. These maps will be shown at the International Geographical Congress which meets at Rome in October next.

I have now come to the end of this rapid sketch of the geographical work of the official world. It is work which, though often of an apparently humdrum character, outweighs in importance the sum total of all which can by any possibility be undertaken by private agency or by societies. But it is the very legitimate business of societies to criticise and encourage.

It is, in fact, not only our manifest duty to encourage the systematic mapping of the world on which we live, but we should do all we can to ensure the perfection, and suitability for their special purposes, of the maps themselves. In the surveying of the earth's surface and its representation by means of maps we are treating of matters which are essentially and peculiarly our own.

It would appear that another great function of Geography, as represented by Geographical societies and congresses, is to serve as a popularising medium for such sciences as geodesy, geology, climatology, and anthropology, and also to serve as the means of bringing together the workers in these sciences. We may be told that so far as this Association is concerned the exact study of geodesy and meteorology is dealt with by Section A, geology by Section C, and anthropology by Section H, but there is, I believe, no other section which forms a more convenient general meeting-ground for all workers in the various divisions of earth-knowledge. We ourselves have our own special work, work which is shared by no others, the great task of mapping the world. This task is such a necessary one, and it is of such genuine value to so many studies, that by assisting in it we are really furthering the Advancement of Science, which is the object of this great Association.

The following Papers were then read:—

1. *Thermal Maps.* *By* Professor A. J. HERBERTSON, *M.A.*, *Ph.D.*

2. *Colour in the Representation of Hill Features.* *By* A. R. Hinks, *M.A.*

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3. *Mean Sea-level.* *By* Captain E. O. Henrici, *R.E.*

In the report of the Royal Commission on Coast Erosion it is stated that there is some evidence that the land on the coasts of Northumberland and Durham is sinking relatively to the sea. The only method of determining whether this is so or not is by means of accurate observations of mean sea-level with reference to marks on shore. The sea-level is, however, constantly altering, not only with the tides but also with the winds, height of barometer, and rainfall. Accordingly, in order to determine what is mean sea-level it is necessary to take observations over a long period of years. Observations at some two dozen stations round the coasts of Great Britain were taken by the Ordnance Survey in 1859, but they were carried out over much too short a period to enable any conclusions to be drawn as to earth movements. There exist some fifteen recording tide-gauges round the coasts of Great Britain, but as they are installed to obtain tidal records for navigation purposes no great degree of accuracy is required, and it is probable that the work of reducing their records to mean sea-level would not be justified by results.

The determination of the relative value of the height of mean sea-level as determined by levelling between the different gauges was carried out in 1860, but it is possible that there may be an error of a foot in the determination of the height of the zero of a tide-gauge as compared with Ordnance datum, and there may also be an error of a foot in the determinations made by the Ordnance Survey of the height of mean sea-level as compared with the zero of the tide-gauge. The values of the height of mean sea-level above or below Ordnance datum varied from 0 to nearly 2 feet, with an average of 0·65 foot above. These variations are about what is to be expected from errors of observation, and do not afford any evidence that mean sea-level is not constant round our coasts.

4. *The Height of Ruwenzori.* *By* Captain E. O. Henrici, *R.E.*

It was mentioned in the report of the Committee on the Geodetic Arc in Africa, presented last year at Sheffield,[1] that observations were taken by Captain Jack, R.E., in the course of the geodetic work, to determine the height of Ruwenzori. The computations were not completed by the time Captain Jack had to leave England, and the data were left in my hands.

The initial mark, with reference to which the heights were determined, was the station peg at Lake Albert Station. The heights of all the stations observed in the arc triangulation were computed, and the probable errors of the results rigidly determined.

From three of these stations, viz., Omunturok, Oruha, and Kasunju, horizontal angles were observed into the highest point of Ruwenzori. These agreed well, giving the position of the highest point 0° 23′ 10″·690 N.lat., and 0° 49′ 31″·949 long. west of Kicherere.

This gives the position of the highest point of Ruwenzori: 0° 23′ 10″·690 N. lat., 29° 52′ 15″ E. long.

Vertical angles were observed from four stations, viz., Muruha, Kabuga, Singirro, and Oruha, giving a mean value of 14,768·1 feet above Lake Albert Station, with a probable error of ± 2·1 feet. The mean probable error of the stations from which observations were taken was ± 1·3 foot.

The coefficient of refraction was taken at 0·060, a figure arrived at after a study of the values for the stations on the arc at which reciprocal observations were taken.

The height of Lake Albert Station was arrived at as follows: The mean height of the station peg above the lake, May to July 1908, was 5·30 feet. The mean reading on the tide gauge at Butiaba during the same period was 2·75 feet.

The height of the zero of the tide gauge is given as 617·350 m. above mean

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[1] *Brit. Assoc. Reports*, 1910, pp. 75-76.

sea-level at Mombasa in September 1907 by Mr. Welldon (Egyptian Survey), and by Mr. Landon (Egyptian Irrigation Service) as 617·197 m. in February 1909. Both heights are apparently obtained from a good bench-mark at Butiaba, which is connected both by spirit-levelling and by trigonometrical heights to Entebbe, hence by two years' comparisons of tide-gauges with the railway levels at Port Florence, and hence to Mombasa by the railway levels.

There is no evidence to show the cause of the discrepancy between the two values for the Butiaba tide-gauge, so a mean of the two values has been taken.

We get, therefore: mean height of Lake Albert, May to July 1908, 2,027·9 feet; height of Lake Albert Station, 2,033·24 feet.

The probable error of this latter value may be roughly taken at ± 4·7 feet, hence height of Ruwenzori (highest point), 16,801·3 ± 5·3 feet.

In a paper published in the Royal Geographical Society's Journal for March 1907 the following figures were given: Position, 0° 23′ 0″ N. lat., 29° 52′ 20″ E. long.; height from the best trigonometrical data at the time, 16.619 feet; height as determined barometrically by the Duke of the Abruzzi, 16,814 feet.

This trigonometrical height was arrived at from observations taken under rather unfavourable circumstances from the south, the length of the rays being 100 miles and over.

The discrepancies in position between the new and old values are unimportant; the new values are subject to correction when the arc centre is finally worked out.

The discrepancies in height are due to uncertainty as to the refraction, which has not been taken into consideration in the above probable errors.

The coefficient of refraction may easily be 0·005 out, or even 0·01. The effect of such an error varies as the square of the distance from which the observations were taken, and trigonometrical observations taken from a distance of 100 miles cannot be considered more accurate than *careful* barometric heights, such as those of the Duke of the Abruzzi.

Personally, I am inclined to think that 0·060 is too low a value for the coefficient for Captain Jack's observations, and I should give the height of Ruwenzori as 16,780 feet, with a probable error of 20 feet.

FRIDAY, SEPTEMBER 1.

Joint Discussion with Section C on the Former Connection of the Isle of Wight with the Mainland.—See p. 384.

The following Papers were then read:—

1. *Constructive Waterfalls. By* Professor J. W. Gregory, *F.R.S.*

Waterfalls are among the most effective agents in deepening river valleys, and thus lowering the land. Their influence is usually regarded as solely destructive; but they may, under some conditions, be constructive and act as agents of deposition instead of denudation. This action is well illustrated by some waterfalls in Dalmatia, Bosnia, and Herzegovina.

The Kerka Falls in Dalmatia, ten miles from Sebenico, illustrate a simple type of constructive waterfall. They are due to a barrier of calcareous tufa, which the Kerka River has built up across its valley. The barrier is 130 feet high; the river is subdivided into many channels, and each falls in a succession of cascades over the tufa terraces. Above the barrier is a plain of alluvium, and a short distance up-stream the river flows from two lakes, one of which is eight and a half miles long. The lakes have been formed by the tufa dam, and as this barrier is being raised in height with its advance down-stream, the lakes are being increased in size owing to the action of the waterfall.

The Topolie Falls on the Upper Kerda River afford a clear illustration of the construction of a tufa dam by a waterfall. The fall is about 70 feet in height,

over a tufa barrier which is being deposited by the waterfall. The barrier is advancing down-stream, and the old gorge of the Kerka River, or as it is there called, the Kerkic River, is accordingly being filled with alluvium. When the falls have advanced another 500 yards, the river will leap from a hanging valley on to the floor of the Knin Basin.

The famous falls at Jajce, the ancient capital of Bosnia, are due to the leap of the Pliva River, from a hanging valley over a tufa sheet, 80 feet thick, into the Urbas River. Some Neolithic remains show that about 60 feet of the tufa has been deposited at Jajce during and since Neolithic times. The Pliva River has cut a notch through the old sheet of tufa which it had previously deposited, owing to an increase in the gradient of the river caused by other tufa bars erected further up its valley.

These three waterfalls show that the ordinary waterfall action may be reversed; waterfalls may advance instead of retreat, may fill up valleys instead of excavating them, may form alluvial plains instead of destroying them, and may make lakes basins instead of draining them. Waterfalls may also form hanging valleys.

2. *Tidal Movements in the Deep Water of the Skagerrak and their Influence upon the Herring Fishery. By* Professor O. PETTERSSON.

The most prominent feature in the hydrographic state of the eastern side of the North Sea, and its tributaries, the Baltic, the Kattegat, the Skagerrak, and the Scandinavian fiords, is the stratification of the waters in layers of different origin discernible by difference in their temperature and salinity. The boundary surface between two adjacent water-layers can, as a rule, be located with considerable accuracy, and by means of a registering apparatus changes in the level of the deep water (as distinguished from the surface water) can be ascertained. A study of these changes conveys the idea of a train of big submarine or boundary waves. This wave movement seems to have its origin in the deep water, as the surface water enters or is expelled from the fiord, whenever there is a subsidence or upheaval of the deep water. There are small boundary waves of two to three days' period, which are evidently seiches of the deep water inside the fiord, since they do not correspond to analogous movements of the deep water of the Skagerrak outside the fiord, and there are great boundary waves of thirteen to fourteen days' period, which are not confined to the fiord, but are in most cases felt on the other side of the Skagerrak. The great boundary waves seem to correspond in their period to the changes in the position relatively to the earth of the sun and the moon; (*a*) the regular train of such waves begins with the autumnal equinox and ends in the following April, the biggest waves thus occurring when the earth is in perihelion; (*b*) the phases of the moon, but still more its declination and distance from the earth, seem to have influence upon the occurrence of the big waves.

It seems obvious that the motions of the deep water are of a tidal nature, and it seems possible that they belong to the special classes of such phenomena called tidal seiches, *i.e.*, movements of the waters of a limited basin caused by the passages of the oceanic tidal waves over its threshold. To investigate this theory, tank experiments were conducted, from which it would appear that the original tidal wave, whether it be forced or free, is modified by its impact upon every submarine ridge it encounters, and gives birth to tidal phenomena of various kinds which can, however, always be recognised by their periodicity.

The occurrence of big boundary waves seems to exercise an influence upon the arrival of the herring shoals on the coasts of Sweden in autumn and winter. It is well known that the fish life of the ocean has its highest frequency where the movement of the waters is most intense. Investigations show that since 1753 the herring fishing has been most prolific in years of maximum declination of the moon and least prolific in years of minimum declination. A high declination causes a more energetic movement of the waters of the innermost parts of the North Sea and its inlets. In summer the herring shoals are spread over the whole northern plateau of the North Sea, and in winter are found concentrated in the eastern and southern parts. The chief agent is the sun's

declination (and the earth's perihelion), which causes the yearly period. The influence of the moon, on the other hand, upon the movement of the deep water causes the periods of abundant and scarce fishing every eighteenth or nineteenth year.

MONDAY, SEPTEMBER 4.

Joint Discussion with Sections C and K on the Relation of the present Plant Population of the British Isles to the Glacial Period.—See p. 573.

The following Paper was then read:—

British Exploration in Dutch New Guinea.
By Captain C. G. Rawling, *C.I.E.*

The object of the expedition, which was organised by the Ornithologists' Union, assisted by the Royal Geographical Society, was to survey the south-western part of Dutch New Guinea, and to study the flora and fauna of the districts. The expedition was led at first by Mr. W. Goodfellow, who acted as ornithologist, and after his departure by Captain Rawling. A landing was effected near the mouth of the Mimika river, where a base camp was formed. The party then advanced along the Mimika to Parimau—thirty miles in a direct line from the coast—where a base was established. The whole of the intervening country was covered with a dense growth of *Pandanus*, *Artocarpus*, *Ficus*, *Rattans*, and other plants. From Parimau attempts were made to penetrate into the mountains, but at first with little success. The Mimika proved useless as a means of advance, and the expedition was forced eastwards across and along the great rivers Kamura, Wataikwa, and Iwaka. A branch of the Wania was then followed for some distance, after which the exploring party made for the foothills, eventually reaching an elevation of 6,000 feet. Here a magnificent view was obtained. To the south lay the densely forested plains and foothills, while to the north was the Nassau Range with its steepy precipitous front, which is over eighty miles in length and varies from 8,000 to 10,500 feet in sheer height.

Among other results of the expedition large and valuable collections of birds and animals were made, together with botanical and ethnographical specimens. A new and unknown race of pigmies was discovered and studied; over 3,000 square miles of country were surveyed and mapped; and the impossibility of the Mimika, and the value of the rivers further east, as a line of advance to the snows, was ascertained.

TUESDAY, SEPTEMBER 5.

The following Papers were read:—

1. *International Air-Map and Aeronautical Marks. By* Ch. Lallemand.

The author described the resolutions recently adopted, at his suggestion, by the Permanent Committee for Aerial Navigation of the Public Works Department of the French Government on the subject of the production of an International Air-Map and the establishment of marks required by aviators and aeronauts. The map, designed on the scale of 1 to 200,000, after a provisional model submitted by the Aero Club, will be a subdivision of the 'International Map of the World,' on the scale of 1 to 1,000,000, for the production of which a common agreement was recently arrived at between the principal States of the

civilised world. Each sheet of the air-map will cover an area of 1° in longitude by 1° in latitude. Twenty-four sheets of the same map will cover the same area as one of the sheets of the international map on the scale of 1 to 1,000,000, since each of the latter covers 6° in longitude by 4° in latitude. In order to avoid the troublesome distinction between eastern and western longitudes, northern and southern latitudes, with the inevitable errors caused by the change of sign, the longitudes are to be reckoned from 0° to 360°, in an easterly direction, extending from longitude 180° E. or W. of Greenwich. In addition, there will be given, instead of latitudes, *polar distances*, reckoned from 0° to 180°, extending from the South Pole, in order that, in the northern hemisphere, where lie most of the inhabited lands, the numbers may increase in the customary way with increasing distance from the equator. Each sheet will be numbered by the co-ordinates of its South-Western corner. In addition, marks, each of which is the distinguishing figure of half a rectangle, with the small sides duly set towards North, should be drawn on the roofs of convenient buildings or on the ground itself. Each of these marks indicates the northern or southern half respectively of the corresponding sheet of the aeronautical map. On each mark a large dot will indicate the proper position occupied on the sheet itself by the mark on the ground. Moreover, two large figures will be marked on each side of the rectangle, set towards North; the left one of which showing the number of the units of degrees of the latitude of the mark, and the right one the number of the units of degrees of the longitude. A mistake of 10°, say 400 miles in the direction of the parallels or 700 miles in that of the meridians, being scarcely probable, these two figures will suffice to define the number of the corresponding sheet of the map and the rough co-ordinates of the mark.

If the example thus given by France should be followed by other countries, an international agreement would be necessary to fix positively the conventional signs of the aeronautical map and other particulars.

2. *Aeronautical Maps.* *By* Captain H. G. Lyons, *F.R.S.*

Cartographers must now treat the material at their disposal so as to meet the requirements of aerial navigation, as well as those of travellers by land and by sea, and for this purpose they need the assistance of those who possess practical experience of this new means of transport. Considerations of economy urge that existing scales should be utilised if practicable with such modifications in the information included in the maps as may be desirable. National and international committees are approaching a common basis of agreement on such points as projection to be employed, scale to be adopted, and the identification of localities. There remain these important groups of data which offer many points for discussion by the cartographer and the aviator.

(i) The relief of the land surface must be adequately represented, and show both altitude and slope, so that they may be readily recognised.

(ii) The detail forming the body of the map needs careful compilation, so as to show all that is essential, while eliminating all that is of lesser importance sufficiently to provide a map clearly and boldly drawn. Natural features, communications, settlements, and prominent objects may need a treatment somewhat different from that in topographical maps to obtain the best results.

(iii) Special information must be added which is important to aviators to indicate localities where assistance may be obtained, or where especial dangers or facilities are to be met with. The efficient assemblage of all such information to the best advantage is not the work of a draughtsman, but calls for the skilled co-operation of the technical cartographer and the experienced aviator.

3. *A Class of Map-projections—retro-azimuthal.*
By J. I. Craig, *M.A.*, *F.R.S.E.*

Two conditions are necessary to determine a map-projection. In a wide and useful class, one condition is that every point shall be in its true bearing from a central point. The class of projection now proposed is such that a central

point lies in its true bearing from every other point, which is not the same thing as in zenithal projections, owing to curvature of the earth's surface. This principle has already been applied by the writer,[1] to the construction of a map where Mecca is represented in its true bearing at every point, and this map has been found useful in Egypt and India.

Professor Hammer[2] has considered a modification such that the back azimuth of every point is given at the centre, while distances from the centre are correct; and Professor Maurer[3] had previously considered a map where every point of a central meridian possesses this property of retro-azimuthality. The writer proposes a new projection, which gives both the true bearing of every point at the centre and the true bearing of the centre at every point.

4. *A Numerical Estimate of the Errors of various Projections for Atlas Maps.*

By A. R. HINKS, *M.A.*

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[1] 'The General Theory of Map-Projections,' by J. I. Craig, Cairo, 1910.

[2] *Pet. Mit.*, 1910, p. 153.

[3] *Ibid.*, 1911, p. 255.

SECTION F.—ECONOMIC SCIENCE AND STATISTICS.

PRESIDENT OF THE SECTION.—THE HON. W. PEMBER REEVES.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

Land Taxes in Australasia.

OUGHT I to apologise for opening this session with an address of a local rather than a general character? I am not sure. At any rate, I can plead that the locality is a wide one. The largest feature of Australia and New Zealand is their territory, and with that territory the subject of this address is directly concerned. It is true that I am asking you to consider the experiments of a white population of but five millions and a half. But the interest of experiments is not limited by the numbers of the men who make them. The potentialities of Australasia are really great. Distance and climatic difficulties in the case of Australia, distance and a broken surface in the case of New Zealand, are mainly responsible for limiting the increase of population to, say, a hundred thousand a year. But though one-third of Australia and, perhaps, one-seventh of New Zealand are hopeless desert or impracticable country, almost valueless save for minerals, still that leaves immense expanses that will carry people, and carry people ever less sparsely as the decades go on. Because Australasia does not fill up at the pace of North America, we are not to suppose that her communities are not growing and will not grow. The experimental laws of which I am to speak may, and I think will, affect the destinies of considerable and highly civilised nations at the Antipodes. Moreover, we live in days when the statesmen of distant countries are quick to take hints from each other's successes. If these Australasian land-taxing laws should in the next twenty years achieve the objects of their framers, it will be odd if they are not imitated in more countries than one.

What are these objects? The primary object of every Government in imposing taxation is supposed to be to raise revenue. Certainly this has been one of the aims of the colonial land-taxers. In the case of some of them, notably of those who imposed the land tax of New South Wales, it was their chief aim. But for the most part revenue has not been their chief object. Most of the land taxes have been, and are, policy taxes, put on with the avowed intention of sharply stimulating the subdivision of land. It is this unconcealed aim, this political and economic intention, which gives them their interest to students. They are the chosen weapons of the progressive and labour parties in their battle against *latifundia*. This is not the arena to discuss whether they are fair or unfair, justifiable or unjustifiable, weapons. At any rate I do not mean to consider them from that standpoint. I propose to say something very briefly of the conditions which stirred popular opinion to bring them about; of their rates and incidence; and of their success or failure as instruments for combating what their friends call land monopoly. The taxes to which I shall refer are those imposed by the States of Victoria, New South Wales, South Australia, and Western Australia, that of the Dominion of New Zealand, and last, but not least, the new Federal tax of the Commonwealth of Australia. These do not by any means entirely represent the annual sum exacted from real property in the seven Colonies. The State Government of Tasmania levies a tax on real property.

Then there are the local rates, which exceed in total amount the direct imposts of the central authorities. Taken altogether, the holders of real property in Australasia pay perhaps seven millions per annum in rates and taxes. But the rates are not everywhere levied on the unimproved or ground values. In some Colonies, or localities in Colonies, they are—notably in Queensland and parts of New Zealand and New South Wales. But the land taxes, except the Tasmanian, fall upon the unimproved value, and most of them are what the rates are not, policy taxes, imposed with several objects, but with one object overshadowing all others.

Here is an Australian official summary of the land taxes and their yields :—

Commonwealth.—500*l.* exemption, then a graduated scale, starting at a penny, 5,000*l.* to 15,000*l.* unimproved value, and rising to 6*d.* on estates of 75,000*l.* and above, with an extra tax in all cases without exemption for absentees.

New South Wales.—Uniform rate of 1*d.* in 1*l.* on unimproved value.

Victoria.—Uniform rate of 1½ per cent. on capital value, with 50 per cent. increase on absentees. (A Bill has lately been under consideration for a graduated tax on unimproved values starting at ½*d.* in 1*l.* from 500*l.* to 2,500*l.*, gradually rising until it amounts to 3*d.* on estates valued at 80,000*l.* and upwards.)

South Australia.—Graduated tax of ½*d.* in 1*l.* to 5,000*l.* and 1*d.* above 5,000*l.* on unimproved value—absentees 20 per cent. increase.

Western Australia.—Uniform 1*d.* in 1*l.* on unimproved value of land not improved; ½*d.* in 1*l.* on unimproved value of land where improved; absentees 50 per cent. increase.

Tasmania.—Graduated tax of ½*d.* in 1*l.* on total capital value to 5,000*l.*, rising to 1*d.* in 1*l.* on 80,000*l.* and over.

New Zealand.—Uniform tax of 1*d.* in 1*l.* on unimproved value, and additional graduated tax of $\frac{1}{16}$*d.* from 5,000*l.* to 7,000*l.*, rising till it amounts to 2*l.* 10*s.* per cent. on estates over 200,000*l.*; absentees 50 per cent. increase.

These are the various taxing measures in existence and proposed. In 1908-09 the tax collected in New Zealand yielded 604,900*l.*, and in the Commonwealth States as follows :—

	£
New South Wales	80,794
Victoria	85,559
South Australia	92,158
Western Australia	33,120
Tasmania	59,651
Total	£351,282

In 1909-10 the yield of the State land taxes in Australia fell to about 330,000*l.* In 1910-11 the New Zealand tax produced 629,000*l.*

As already indicated, the main though not the sole object of most of the land taxes has been to stimulate the subdivision of land. To how great an extent land monopoly held New Zealand and Australia in its grip twenty years ago may be indicated in a single sentence. At that time in the four Colonies of New South Wales, Victoria, New Zealand, and South Australia about 2,100 proprietors (companies or persons) held about 43,000,000 acres of land in freehold. A great deal of this was good land; much of it very good. Very little of it was utterly bad land. Most of it was well placed, so as to be accessible for settlement. But in the main it was occupied for grazing; and purely pastoral occupation in Australasia means population of the scantiest kind. This differentiates the large holdings of the Antipodes from the landlord and tenant system of England. In England you have what to colonial eyes seems a numerous rural population. On the great pastoral estates of Australasia the population is of cattle and sheep. I am speaking now of freeholds, and not of the even vaster pastoral tracts held on lease or under grazing licence from the Crown. Most of the territory now held in this last-mentioned fashion is, to speak frankly, not suited for close settlement. Moreover, where it is fit for any sort of subdivision the Colonial Governments have the remedy in their own hands. They can cut the runs up as the leases fall in. In some cases they do this. In others they are

satisfied to raise rents or to make no change. But the pastoral licensees, the so-called 'squatters,' have ceased to be the chief targets of the agitators for land reform. That unenviable position is now held by the great freeholders. It is at them that the land taxes are aimed, though, by the way, Crown tenants are liable to pay land taxation to the extent of the unimproved value, if any, of their leasehold estate.

Apart from rates, taxes, and public criticism, the economic position of the large freeholders of Australia and New Zealand has been in recent years highly agreeable. Grazing pays well, and, with few exceptions, their lands are now worth very much more than the sums originally paid for them to the State. In the Parliament of Victoria last year it was pointed out by the Prime Minister that from first to last Australia had sold about 123,000,000 acres of public land for, roughly speaking, the same number of pounds. The average price had been about 1*l.* per acre. The land sold in Victoria was one fifth of the whole. But the unimproved value of this Victorian land was last year reckoned at 127,500,000*l.* That is, it was several millions more than the original price of all the private freehold of Australia. Moreover, this assessed value of the Victorian land was probably considerably under its real value. In New Zealand the great estates have been bought from the Crown at prices varying from 5*s.* to 2*l.* per acre. During the last twenty years the Government there has spent some six millions in buying back about 1,400,000 acres for closer settlement.

Now for a word or two on the various land taxes. The pioneer land-tax, the Victorian, was imposed by a law enacted in 1877. It affected only rural land, and only estates worth more than 2,500*l.* Its rate was 1¼ per cent. on the capital value of land. But by an absurdly stiff and artificial system of valuation, no land could be held to be worth more than 4*l.* an acre. The incidence of the tax worked out at 9½*d.* an acre on the dearest land and 2½*d.* on the cheapest. Its practical effect was to extract annual sums from 85,000*l.* to 125,000*l.* out of the pockets of between eight and nine hundred substantial proprietors. As a stimulus to subdivision it has been remarkably ineffective. This is all the more curious because it was proposed as a bursting-up tax, and fiercely resisted on that account. The South Australian land tax was imposed in 1884, and stiffened by graduation in 1890. But even on absentee large owners it is but 1½*d.* in the pound capital value, and its effects on *latifundia* have been very small. The New South Wales tax was light, was not graduated, and was mainly imposed for revenue purposes. Owing to its partial repeal or suspension the receipts from it fell from 345,000*l.* in 1907 to 80,000*l.* It did nothing but provide the revenue thus decreased. Mr. Coghlan says of it: 'The results were undoubtedly unsatisfactory. The revenue was small, the cost of obtaining it large, and the formation of large estates—which the Act ostensibly sought to prevent—was not discouraged.' The West Australian tax is light, and has no history. It has been law for only four years. The distinction which it draws between improved and unimproved land and its doubled tax on the latter are interesting. The Tasmanian tax is levied for revenue purposes.

On the whole, then, previous to the levying this year of the Federal land-tax by the Commonwealth Government, the Labour Ministry and the Australian States had done little. They were extracting 331,000*l.* by land taxes out of communities whose total annual taxation was between fourteen and fifteen millions sterling. How utterly their taxes had failed in bursting up the great freeholds a few figures will show. I will quote those given in debate last year in the Commonwealth Parliament by Mr. Hughes, the Attorney-General of Australia:—

> It appears that there are 3,140 landowners in Australia, the unimproved value of whose estates is 5,000*l.* and under 6,250*l.* each. There are 4,926 landowners who have estates of between 6,250*l.* and 12,500*l.* in unimproved value; 1,095 landowners whose estates run between 12,500*l.* and 25,000*l.* each in unimproved value; and 766 landowners who have estates of over 25,000*l.* unimproved value each, the aggregate unimproved value of the last-named being 48,190,000*l.* Roughly speaking, there are fewer than 11,000 who will pay under this tax, including absentees. There may be fewer than 11,000, and I think there will be, but we are unable to tell. A man may have aggregations of estates in various States, and so it is impossible to compute the number exactly: but, roughly speaking, 10,000 persons own 127,000,000*l.* worth of unimproved land values—that is to say, reckoning the

unimproved value to be 50 per cent. of the total value, 10,000 persons own about 254,000,000*l.* worth of landed interests in the Commonwealth, or one four-hundred-and-fiftieth of the population own three-eighths of all the landed interest of Australia.

Elsewhere in the same speech last year it was stated that 'in seven years the number of the estates in New South Wales which exceed 5,000 acres has increased from 1,282 to 1,366, the number of those which exceed 10,000 acres from 703 to 728, and the number of those which exceed 20,000 acres from 351 to 360. In Western Australia the number of estates exceeding 5,000 acres was 147 in 1901, and 242 in 1909; while of those exceeding 10,000 acres the increase was from 74 to 102, and of those exceeding 50,000 acres from four to six. The Victorian "Land Tax Register" of August 2, 1910, stated that there were 2,000,000 acres in the Western district held by 187 persons, and that there are four estates exceeding 50,000 acres each, 14 exceeding 30,000 acres each, and 77 exceeding 5,000. In New South Wales there are 104 estates exceeding 50,000 acres each.' Again, Mr. T. A. Coghlan, writing of the land tax in New South Wales, says: 'When the Act was imposed in 1895 there were 4,448 estates ranging in size from 1,000 to 10,000 acres, and comprising an area of 11,800,000 acres. In 1907 the number of such estates had increased to 6,000, with an area of 15,000,000 acres. Of holdings of 10,000 acres and upwards there were 656 in 1895, embracing an area of 20,600,000 acres; whereas in 1907 the number had grown to 729, with an area of 23,000,000 acres.'

The tax on the unimproved value of land in New Zealand dates from 1891, when it was imposed after a sharp parliamentary struggle. As already mentioned, *latifundia* then existed there on a grand scale. Not half the country was occupied even loosely. Yet 585 corporations or individuals owned between ten and eleven million acres—that is to say, fully one-third of the occupied territory. Two-thirds of one per cent. of the landowners held 40 per cent. of the land. One-eightieth of the country landowners held two-fifths in value of the rural land. As late as 1891 large landowners were buying still more land. The Colony was depressed; population was leaving the islands; efficient settlers complained that land was not to be got. A uniform property tax of 1*d.* in the pound on all real and personal estate over 500*l.* in value was extremely unpopular. For this a land tax of 1*d.* on unimproved values was gradually substituted by laws passed in 1891 and 1893. In practice this meant that 1*d.* in the pound which the property tax had levied on the improvements and live-stock of farmers was no longer exacted—a great relief to the smaller working settlers. An income tax took the place of the property tax on personalty, but was not, and is not, levied on incomes derived from land, a distinction to be noted by English students.

The flat land tax of 1*d.* in the pound would not by itself have disturbed the larger New Zealand holders. But specially aimed at them was a graduated tax on all values over 5,000*l.* This, beginning at ⅛*d.*, rose by eighths till on unimproved values of 210,000*l.* and upwards it reached 2*d.* in the pound of capital value, with an extra percentage for absentees. This, added to the flat land-tax, appeared severe. Moreover, the payers of the graduated tax were not allowed exemption to the extent of their mortgages, a privilege accorded to payers of ordinary land-tax. The tax was spoken of as confiscatory. Yet during the ten years in which the graduated scale of 1893 remained in force it did extremely little to break up the great estates, and the revenue it yielded only increased from 71,000*l.* in 1893 to 79,000*l.* in 1903, though the price of land had risen sharply, and prosperity had returned as early as 1896. Parliament, therefore, revised the scale of graduation on all land values of 7,000*l.* and upwards. The steps were thenceforth of $\frac{1}{16}$*d.* instead of ⅛*d.*, and rose to a maximum of 3*d.* instead of 2*d.* A central and efficient department of land valuing was set up. Assessment on uniform principles was made reasonably accurate, while at the same time there was not undue harshness. These changes, combined with the continued rise in the selling value of real estate, had their result. In six years the combined yield from the flat tax and the graduated tax slightly more than doubled. It rose from 296,000*l.* in 1903 to 605,000*l.* in 1909. The yield of the graduated division increased from about 79,000*l.* to 215,000*l.*

This, from the point of view of the Exchequer, was satisfactory enough. The middling landowners were paying substantially; the great ones were paying heavily. But the failure to burst up the large properties into small farms

continued. No one had expected that the tax would do this suddenly. But in 1891 it had certainly been thought that noticeable progress would have been made, say, in fifteen or sixteen years. And at first sight the subjoined table would seem to show that such progress was made :—

Rural Freeholds of 10.000 *Acres and Over.*

Year	Number of Owners	Total Areas in Acres	Total Capital Value	Total Unimproved Value
			£	£
1891	262	7,840,202	17,457,598	12,200,329
1902	216	6,115,491	13,494,164	9,563,422
1906	204	4,704,542	12,250,074	9,278,253

That from the land reformers' standpoint looks well. But here is a table showing the number of rural holdings of different grades of size, from those of 5 acres upwards. There are thirty-two grades. The lowest comprises holdings of from 5 to 10 acres; the highest, holdings of 150,000 acres and over. The table shows that from the year 1892 to 1906 the freehold estates between 3.000 and 10.000 acres in size increased in number by nearly 200—from 463 to 652. Those between 1,000 and 3,000 acres increased in number by 740. That is not the way to get close settlement or population. Here is the table :—

Number of Rural Freeholds in the Years 1892 *and* 1906.

Acres	1892	1906
5 and under 10	2,820	3,512
10 ,, 20	3,015	3,775
20 ,, 30	2,267	2,575
30 ,, 40	1,428	1,623
40 ,, 50	2,318	2,106
50 ,, 60	2,612	2,399
60 ,, 70	1,463	1,378
70 ,, 80	1,162	1,160
80 ,, 90	1,423	1,314
90 ,, 100	1,061	1,118
100 ,, 200	8,267	8,740
200 ,, 320	4,575	5,560
320 ,, 500	2,531	3,520
500 ,, 640	1,022	1,587
640 ,, 1,000	1,143	1,862
1,000 ,, 2,000	992	1,553
2,000 ,, 3,000	311	490
3,000 ,, 4.000	146	227
4,000 ,, 5,000	109	147
5,000 ,, 6,000	66	78
6,000 ,, 7,000	50	75
7,000 ,, 8,000	38	56
8,000 ,, 9,000	29	27
9,000 ,, .0,000	25	42
10,000 ,, 20,000	148	129
20,000 ,, 30,000	45	40
30,000 ,, 40,000	30	14
40,000 ,, 50.000	9	8
50,000 ,, 75,000	14	8
75,000 ,, 100,000	6	4
100,000 ,, 150,000	6	—
150,000 and over	6	1
Total	38,935	45,068
Increase holdings	6,133	

Moreover, of such subdivision into small holdings as there has been, a substantial share has been plainly due to another cause than the land tax. In 1892 the New Zealand Government began to re-purchase large estates, or parts of them, and to cut them up and lease them. In this way it has bought about 1,400,000 acres, for about 6,000,000*l.* (including cost of subdivision), and withdrawn them from the acreage held by the large men.

In 1907, therefore, the Government decided to recast the graduated tax so far as applicable to unimproved values of 40,000*l.* and over. The scale was so arranged that values of 200,000*l.* and over were to be charged 2*l.* per cent. in addition to the ordinary 1*d.* flat tax. Again, after March 1910 the graduated tax was to be further raised by 25 per cent. on the classes of especially large properties above 40,000*l.* All I know of the effect of this last change is that it has not added greatly to the total amount collected by the Treasury under the head of land tax. That amount is 629,000*l.* for the year ending with March 1911. That may mean that a number of the greater estate owners have bowed to the blast and cut up their properties. I understand that the Premier of New Zealand states as much. But then the question arises, Of what kind has the subdivision been? We have seen that a decline of the very large estates may be coincident with a growth in the number of fairly large properties. Moreover, there is such a thing as subdivision which is legal but not economic. There are family and other arrangements by which the law is observed, which are not fraudulent or morally wrong, but by which the tax may be evaded. I refer to such expedients as gifts, declarations of trust, collusive sales and leases. In a speech in the New Zealand Legislative Council in 1907 Sir John Findlay, K.C., the Attorney-General, credited such legal expedients with no small share in baffling the policy of the land tax. We have yet to see, therefore, what the real result of the tax as now imposed is, though I believe that a certain amount of genuine and economic subdivision is going on. Doubtless, the effect of the land tax has been checked by the long period of prosperity enjoyed by New Zealand. The large holders have made much money, and the rising price of land has tempted them to hold on for better and better prices.

I have dwelt on this New Zealand tax because it is the most thorough-going thing of the kind in the Colonies that has any history. Because, too, it was the model taken by the Labour leaders in Australia for their more important Federal land tax, and because from the experience of New Zealand we may deduce something which may enable us to look ahead at the prospects of the Australian experiment.

I will here insert an official table showing the incidence of the graduated portion of the New Zealand land tax :—

Graduated Land Tax: Rates of Graduated Land Tax.

Where the total Unimproved Value of all the land of any taxpayer is not less than	And is less than	The Rate of Graduated Land Tax on such total Unimproved Value is	
£	£		
5,000	7,000	$\frac{1}{16}$	of a penny in the pound sterling.
7,000	9,000	$\frac{2}{16}$	
9,000	11,000	$\frac{3}{16}$	
11,000	13,000	$\frac{4}{16}$	
13,000	15,000	$\frac{5}{16}$	
15,000	17,500	$\frac{6}{16}$	
17,500	20,000	$\frac{7}{16}$	
20,000	22,500	$\frac{8}{16}$	
22,500	25,000	$\frac{9}{16}$	
25,000	27,500	$\frac{10}{16}$	
27,500	30,000	$\frac{11}{16}$	
30,000	35,000	$\frac{12}{16}$	
35,000	40,000	$\frac{13}{16}$	

At the value of 40,000*l.* the rate is 8*s.* per cent., and for every additional 1,000*l.* of land value the rate is increased by $\frac{1}{5}$*s.*, the increased rate in each

graduation being chargeable on the total land value owned. The rate reaches its maximum at 200,000*l.*, all estates of that value and over paying at the rate of 2*l.* per cent. on the total land value.

For and after the year ending March 31, 1910, the new progressive graduated scale over 40,000*l.* has been increased by 25 per cent. in the case of all land other than 'business premises.'

The graduated land tax is increased by 50 per cent. in the case of absentees, and it is made clear that the absentee tax does not apply to companies.

The graduated rates of the Australian Federal land tax, which became law in November 1910, may be found in the schedules of the Act and in an explanatory memorandum issued by the Commonwealth Government. The tax is levied on values over 5,000*l.* when owned by residents and on all land held by absentees. The latter class also pay under special scale. The following are the rates :—

Rate of Tax when Owner is not an Absentee.

For so much of the taxable value as does not exceed 75,001*l.*, the rate of tax per pound sterling shall be one penny where the taxable value is one pound sterling, and shall increase uniformly with each increase of one pound sterling in the taxable value, in such manner that—

the increment of tax between a taxable value of 15,000*l.* and a taxable value of 15,001*l.* shall be 2*d.* ;
the increment of tax between a taxable value of 30,000*l.* and a taxable value of 30,001*l.* shall be 3*d.* ;
the increment of tax between a taxable value of 45,000*l.* and a taxable value of 45,001*l.* shall be 4*d.* ;
the increment of tax between a taxable value of 60,000*l.* and a taxable value of 60,001*l.* shall be 5*d.* ; and
the increment of tax between a taxable value of 75,000*l.* and a taxable value of 75,001*l.* shall be 6*d.*

For every pound sterling of taxable value in excess of 75,000*l.* the rate of tax shall be 6*d.*

The rate of tax for so much of the taxable value as does not exceed 75,000*l.* may be calculated from the following formula :—

R = rate of tax in pence per pound sterling.
V = taxable value in pounds sterling.

$$R = \left\{ 1 + \frac{V}{30{,}000} \right\} \text{pence.}$$

Rate of Tax when Owner is an Absentee.

For so much of the taxable value as does not exceed 5,000*l.* the rate of tax per pound sterling shall be one penny.

For so much of the taxable value as exceeds 5,000*l.*, but does not exceed 80,001*l.*, the rate of tax per pound sterling shall be twopence where the excess is one pound sterling, and shall increase uniformly with each increase of one pound sterling in the taxable value in such manner that—

the increment of tax between a taxable value of 20,000*l.* and a taxable value of 20,001*l.* shall be 3*d.* ;
the increment of tax between a taxable value of 35,000*l.* and a taxable value of 35,001*l.* shall be 4*d.* ;
the increment of tax between a taxable value of 50,000*l.* and a taxable value of 50,001*l.* shall be 5*d.* ;
the increment of tax between a taxable value of 65,000*l.* and a taxable value of 65,001*l.* shall be 6*d.* ; and
the increment of tax between a taxable value of 80,000*l.* and a taxable value of 80,001*l.* shall be 7*d.*

For every pound sterling of taxable value in excess of 80,000*l.* the rate of tax shall be 7*d.*

The rate of tax for so much of the taxable value as exceeds 5,000*l.* and does not exceed 80,000*l.*, may be calculated from the following formula :—

R = rate of tax in pence per pound sterling.
E = excess of taxable value over 5,000*l.* in pounds sterling.

$$R = \left\{ 2 + \frac{E}{30,000} \right\} \text{pence.}$$

The tax has been levied throughout Australia, and is expected to bring in from 1,350,000*l.* to 1,500,000*l.* Australian landowners have to pay, irrespective of mortgages and in addition to the Federal tax, about 330,000*l.* in State land taxes, or about 1,800,000*l.* altogether, as compared with about 630,000*l.* paid in New Zealand. If I were to put the gross selling value of the landed estates of Australia at 680,000,000*l.* and that of New Zealand at 280,000,000*l.*, I might not be utterly wrong. But very much of this huge value—which includes improvements—is exempted from the operation of land taxes. Even in Western Australia there is an exemption of 50*l.* of unimproved value from the State tax; in New South Wales of 240*l.*; in New Zealand of 500*l.* The Commonwealth tax does not touch values under 5,000*l.* except in the case of absentees. In New Zealand two years ago less than 31,000 landowners paid land tax, though at that time there were 143,000 freeholders and 25,000 Crown tenants in the Dominion.

Fortunately I can give you some information as to the comparative incidence of the new Federal land-tax with the incidence of the New Zealand tax as it was previous to April 1909. The Australian Government prepared a comparative table showing this. The table shows that on land values between 5,000*l.* and 40,000*l.* the Australian tax is much lighter on resident landowners, though rather heavier on absentees. On the upper grades the Australian tax is noticeably heavier.

Comparative Statement of Amounts payable under Australian and New Zealand Acts.

Total Unimproved Value of Estate	Amount of Tax payable											
	Australia						New Zealand					
	Resident			Absentee			Resident			Absentee		
£	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
5,000	—			20	16	8	22	2	8½	22	10	9
10,000	24	6	1	65	19	5	49	9	7	53	7	8½
15,000	55	11	1	118	1	1	85	18	9	97	13	1½
20,000	93	15	0	177	1	8	125	0	0	145	16	8
30,000	190	19	5	315	19	5	218	15	0	265	12	6
40,000	315	19	5	482	12	9	325	0	0	405	0	0
50,000	468	15	0	677	1	8	458	6	8*	583	6	8*
60,000	649	6	1	899	6	1	610	0	0*	790	0	0*
70,000	857	12	9	1,149	6	1	781	13	4*	1,026	13	4*
80,000	1,093	15	0	1,427	1	8	973	6	8*	1,293	6	8*
90,000	1,357	12	9	1,732	12	9	1,185	0	0*	1,590	0	0*
100,000	1,649	6	1	2,065	19	5	1,416	13	4*	1,916	13	4*

* These are the amounts that were payable under the rates in force to March 31, 1909.

It must be remembered, too, that in Australia we must reckon the State taxes. Land taxation on big estates in Australia would therefore seem now to be heavier than that of New Zealand was in the years between 1893 and 1909. And it should be especially heavier on the higher grades, where there are State land taxes to supplement it. Shall we, therefore, see the experience of New Zealand repeated so far as a diminution in the number of the very large estates goes? To what extent, if at all, shall we see an increase in the number of middle-sized estates of from, say, 1,000 to 10,000 acres? To what extent wil the subdivision be

legal rather than economic? To what extent will population go on to the soil and new homesteads be built and inhabited? The history of colonial land laws and experiments in settlement has many a strange tale to tell—loopholes discovered in laws, and of legislative designs evaded. On the other hand, Governments and administrators have learned at least something by experience, and public opinion is sincerely in favour of genuine subdivision. Landowners may resent special taxation, but the public resents the locking-up of land, at any rate where it is fairly fertile and well watered. The position is that two severe systems of land taxation now prevail, mainly at the expense of the larger freeholders in Australia and New Zealand. The recent additions to the New Zealand tax should make the two not very dissimilar in severity. Both countries make a special target of absentees. In New Zealand I should fancy that the assessments are not far below the selling value. I should expect the same to be true of the assessments for the Federal land-tax. In both countries local rates are sometimes levied on unimproved land values, sometimes not. In neither has the problem of distinguishing between gross value and unimproved value presented much difficulty. The same may be said of the complications brought in by leases and mortgages. The taxing of unimproved values rather than gross real estate is on the whole thought just. To what extent will the larger Australian and New Zealand proprietors yield? To what extent will they go on paying the greater part of 2,400,000*l*. in yearly land taxes as well as a large share of some 4,000,000*l*. of local rates? The history of the State land taxes shows that those who resisted them when they were imposed were unduly alarmed at them. They have failed to 'burst up.' Even in New Zealand the success of the land tax in that way has been limited. But the taxation, as now levied, is heavier than ever before; and Governments have had experience in drafting acts and assessing land. In good times the landowners may be able to pay up and go on holding, but bad seasons and low prices may make another thing of taxation.

The following Papers were then read :—

1. *Taxation of Land Values.* *By* C. F. BICKERDIKE.

This paper dealt with (1) the national increment value-tax, the question of equity and social consequences, (2) proposals to alter the method of local taxation in such manner as to allow towns having high land values to tax them for the benefit of the locality.

The increment tax can be and has been powerfully criticised on grounds of equity, and the defence has scarcely been adequate. It can be argued with considerable show of reason that this tax is the only one of which it can be said that the whole of the incidence, not only of the immediate but of the future yield, is on a limited number of existing people who are not necessarily wealthier than the rest of the population. To confine the tax to 'windfalls' in the strict sense would reduce the yield to very little. However, an analysis of the social consequences of investment in properties yielding incomes often remote and hazardous, in connection with the theory of interest, suggests some grounds on which a logical distinction can be drawn between a direct tax on present value of land and a tax on future increments of value.

But the principal ground on which can be rested the case for taxation of land values is found in connection with local taxation. Contrary to the general trend of economic opinion, it is argued that it is theoretically desirable that land values should be mainly applied to add to the attractiveness of the localities in which they arise. This cannot be attained in view of vested interests, but the equity of some step in the direction of land value taxation is rightly regarded in a different light when the primary purpose is to remove a hindrance to the most advantageous geographical distribution of population and productive power.

2. *How do Wages vary?* *By* Professor E. WAXWEILER.

The question of the laws that govern wages movements has been met by several economic theories: 'supply and demand,' 'wages fund,' 'productivity of

labour,' 'standard of living,' 'bargain,' to recall here only some of them. In the author's opinion, they are all the outgrowth of a most precarious method of scientific theorising, namely, the generalisation of *concordances that are merely likely to appear*—for instance, when labour becomes more productive, there is no direct connection between this fact and a rise of wages; the opposite frequently happens, namely through the universal practice of 'nibbling' of piece-work prices.

The author claimed that the only way to build up a well-founded theory of wages-variations is to investigate, in the reality of social life, the process of such variations—that is, to observe accurately, both from the side of the employers and employees, what are the circumstances that initiate a rise or a decline of wages. Mere statistics furnish no indications: they only record what has happened, not *how* it happened, while psychological and sociological analysis of the position of bargainers reveals various elements that immediately influence wages. The author undertook some years ago investigations in this direction, and he has already collected a large amount of facts, giving rise to conclusions of which he mentioned some only as instances:—

1. The process of variation is quite different according as the work is piece-rated or time-rated.
2. There is a special chance for rise when the places of employment are numerous.
3. The more the rates of wages are differentiated in the same trade and place of employment, the more wages are liable to rise by means of a kind of social 'leading on.'
4. The process of variation is thoroughly changed when both bargainers (or one of them) are organised.
5. The degree of knowledge of the economic conditions of their industry among working-men affects the process of variation.
6. The process of variation depends as much on the psychological standard of working-men as on their material standard of living.

FRIDAY, SEPTEMBER 1.

1. *Wages and the Mobility of Labour.* *By* Professor A. L. Bowley, *M.A.*

The effect of removing obstacles to the movement of workmen from one place to another was first analysed under hypothetical conditions summarised in the following table:—

Production of Wheat.

		Before movement		After movement	
		District A	District B	District A	District B
		s.	*s.*	*s.*	*s.*
2 quarters, Best land	Cost of production (other than wages)	0	0	0	0
	Rent . . .	40	20	30	30
	Wages: 2 men .	20	40	30	30
2 quarters, Medium land	Cost . . .	20	20	20	20
	Rent . . .	20	0	10	10
	Wages: 2 men .	20	40	30	30
1 quarter, Bad land	Cost . . .	15	No production	15	15
	Rent . . .	5		0	0
	Wages: 1 man .	10		15	15
1 quarter, Worst land	Cost . . .	20	„	No production	
	Rent . . .	0			
	Wages: 1 man .	10			

		A B	A B
10 quarters at 30s. each	Cost	55+20= 75	35+35= 70
	Rent	65+20= 85	40+40= 80
	Wages: 10 men	60+80=140	75+75=150
		300	300
	Average wage	14s.	15s.

Here wages rise in A from 10s. to 15s., and fall in B from 20s. to 15s. The average in A and B together rises 1s. Rent falls in A and rises in B, and the total falls. The cost of production, other than wages, falls.

More general circumstances were then considered, where specialised labour or unemployed labour exists, where labour has a monopoly wage, and where there are many industries, some of increasing return. It was shown that there are some cases in which the wages of all concerned rise, some where they fall temporarily, and some where they fall permanently in one district.

Finally the action of labour exchanges and their relation to standard wages were discussed.

2. *The National Labour Exchanges.* *By* Robert À-Ababrelton, *F.R.G.S.*

These exchanges, controlled by the Board of Trade, were authorised by the 'Labour Exchanges Act, 1909,' and started on February 1, 1910. There are now 200 exchanges in Britain, and it is officially stated that there will probably be 300 by the end of 1911.

At first they were viewed with suspicion by employers and by skilled workmen. These difficulties are being overcome, and skilled men make use of the exchanges in largely increasing numbers. Advisory trade committees are set up, employers and workmen being equally represented thereon. Trade-union branches are making use of the exchange rooms for meetings. The exchanges are impartial to masters and men. No fees are chargeable. Separate departments, with separate staffs of women, are being provided for women and juveniles. Card-index system is used throughout, with an elaborate subdivision of industries for rapid reference. 'Registration' lasts a week, but applicants can 'register' afterwards. Travelling expenses may be advanced. Skilled and unskilled labour are now being separated. In the juvenile department special advisory committees are formed to give information and advice to the young people and to their parents.

The labour exchanges are divided into territorial divisions, each with its central office, which is in constant communication with, and controlled by, the Central Office in London. They are now filling over 10,000 vacancies per week, mostly for skilled labour.

The great adaptability of the system referred to, and suggestion made that it should be extended to our oversea Dominions when suitable opportunity offers.

Indoor domestic servants are precluded from the beneficent work of the labour exchanges.

3. *India with respect to the World's Cotton Supply.*
By J. Howard Reed, *F.R.G.S.*

Shortage of raw cotton has become an almost chronic condition with which the cotton manufacturer has to contend. It has produced abnormally inflated prices, given an opportunity to cotton gamblers, caused loss and embarrassment to manufacturers, and produced distress among cotton operatives. 'Shortage' has not been produced by a falling off of the world's output of raw fibre, nor by an increased demand by Lancashire for cotton, but by an enormous growth in the manufacture of cotton goods on the Continent of Europe and in the United States of America. In eighteen years prior to 1910 Britain's demand for raw cotton has fallen 4 per cent., while during the same period Europe's requirements have increased 70 per cent., and this on a figure much larger than ours. America, during the same time, has increased her demand

90 per cent., and her total consumption of fibre now exceeds that of Britain by no less than 54 per cent. Thirty years ago the total American crop of cotton was less than seven million bales, but, supplemented by the small crops of other countries, was sufficient to supply the world's demands and leave a surplus each season, keeping the price reasonable and fairly regular. Recently, with an American crop nearly double the figure just quoted, and with increased supplies from other fields, and with the demand of Lancashire practically stationary, the price of raw fibre doubled, and 'shortage' became rampant, notwithstanding the restricted time worked in the mills. The difficulty apparently gets worse, and unless measures of amelioration are successfully pressed, the cotton industry of Lancashire must decline, and ultimately be starved out of existence. India at present produces almost half the weight of cotton grown in the American fields, and has roughly 20,000,000 acres under cotton crops. Indian fibre is, however, of short staple and therefore very little used in Lancashire. Britain consumed only 87,592 bales during the year ending August 31, 1910. Many experts believe that with properly directed effort the crop of Indian cotton may be doubled in the course of a few years. If this can be done, even if the staple is not improved, it will take the place of much long-fibred cotton now used throughout the world, and set free for Lancashire a proportionate amount of better material. The cultivation of cotton in India is very primitive. The lands are poorly tilled, inadequately manured, and meagrely watered; while the native farmer is not only very unprogressive, but is harried by unscrupulous money-lenders, crippled by poor seed, and handicapped by insect pests. With selected seed longer-stapled cotton can be grown, but the native ryot finds it gives a lighter crop, and as he can under present conditions only obtain the same price as for the shorter-stapled cotton, he naturally soon reverts to the cultivation of short-stapled fibre. This is largely an economic difficulty, which can be met by the establishment of recognised buying and ginning centres, and the founding of Co-operative Credit Banks, each under scientific and official control. The Agricultural Department of India has done much to improve matters, but larger grants are required to enable it to do more. There is enormous scope for its usefulness. The native people need to be taught better methods of farming, modern agricultural machinery should be introduced, proper rotation of crops insisted upon, ample manuring provided for, better seed made available, honest methods of financing established, and well-placed and easily accessible ginning and buying centres set up. If work of this kind is taken in hand in a thoroughly efficient manner, more acres can be brought under cultivation and the number of cotton cultivators will multiply. The development of railways, roads, and irrigation works, already in a highly organised condition, will advance as the demand for them grows. India has in the past produced better cotton, and can do so again under properly regulated conditions. Any efforts which can bring this about are well worth making, as their success means vast advantage to the agriculturists of India, a relief from serious strain in the cotton world, and the salvation of the great industry of Lancashire.

4. *Calendar Reform: A Suggested Basis of Agreement.* *By* ALEXR. PHILIP.

This paper referred to the pamphlet published by the writer in 1907, entitled 'A Proposal for a Simplified Calendar,' which formed the basis of the Calendar Reform Bill introduced into the House of Commons in 1908, and again in 1911, although that Bill introduced one or two additional matters not included in the writer's original proposal. Similar proposals made on the Continent by Professor Grosclaude, Dr. Koppen, and others led up to a discussion of the subject by the International Congress of Chambers of Commerce in 1910, as a result of which the Swiss Government have invited the Powers to a diplomatic conference on the subject—an invitation which the British Government, amongst others, have intimated their readiness to accept. In these circumstances, the writer proposed to consider whether a basis of agreement can be arrived at between the various proposals which have been mooted.

The fundamental elements of the calendar are the day and the year which

have now been ascertained astronomically with perfect accuracy. The present proposals do not refer to these, but to the intermediate divisions of the week and the month. Whilst in some countries the month was originally a period of 30 days, in others months of 29 and 30 days alternately were adopted in order to conform as nearly as possible to the length of the moon's synodical period, which is a little more than 29½ days. This rendered necessary the custom of introducing an intercalary month, and the consequent confusion and abuse of this practice was the *raison d'être* of the Julian Reform. Julius Cæsar adhered to the grouping of the months in pairs, but added a day to each month except February. Subsequent arbitrary alterations have deranged the symmetry of the months. The arrangement of the months in four groups of three, corresponding to the four seasons and the four quarters of the year would be at once more scientific and more convenient. Such groups consisting of one month of 31 days, and two of 30 days each, make up a year of 364 days, or 52 exact weeks, the 365th day and the odd day in Leap Year being treated as days of the year only and excluded from the weekly and monthly enumeration. Objections have been taken to the application of this principle to the week. Although these seem to be founded on prejudice, or misconception, it is suggested that in the first instance the reform should be confined to the scientific readjustment of the months, to which no objection has been taken, and which could easily be brought into operation by international agreement.

Proposals have been made for converting the calendar months into a multiple of weeks. It is impossible to carry out any symmetrical arrangement of this nature, and no such arrangement is in any case possible unless the principle of the *dies non* is applied also to the weeks. Some new grouping of the weeks might be arranged if the reform be applied to the weeks, but in any case ought not to be allowed to disturb the adjustment of the calendar month as a twelfth fraction of the year.

A brief explanation was given of a number of the statistical and other advantages which would result from the scientific readjustment of the monthly calendar, and a device was described for securing the advantage of a perpetual calendar without any interruption of the weekly succession of days.

5. *Economic Aspects of the Introduction and Establishment of a British Beet-Sugar Industry. By* SIGMUND STEIN.

Great Britain is the greatest sugar consumer in the world. We imported last year (1910) 1,745,129 tons of sugar, of which 1,303,319 tons were beet-sugar, and 441,810 tons cane-sugar. We sent abroad last year £25,307,214 for sugar. The question may well be asked whether we can keep this immense amount of money in our country by producing the sugar ourselves. England distinguishes herself by being the only country in Europe which does not produce a single ounce of sugar herself. I have proved by over four thousand sugar-beet growing experiments, conducted in practically every county in the United Kingdom in the last twenty consecutive years, that we can successfully grow sugar-beet in these islands. The beet cultivation in Germany brought an increase on the yield of all crops. The beet culture forced the farmer to adopt very deep ploughing, along with scientific farming and proper treatment of the soil both chemically and physically. The ingenuity of the agricultural engineer invented new implements and machinery for this new departure in agriculture. The by-products and residue of the beet-sugar industry, called beet-pulp or 'slices,' are a very valuable cattle-food by which the number of cattle could easily be increased, also the fattening of cattle fostered.

In Europe alone fifty millon tons of sugar-beet root are cropped per year. Out of this vast quantity twenty-five million tons of sugar-beet pulp are produced, which are all used for cattle-feeding. This enormous quantity of cattle-food has been the means of considerably increasing the number of cattle on the Continent. England has entirely given herself up to manufacture and neglected agriculture, while Continental countries like Germany, where industry and manufacture have increased and improved at the same pace as ours, have not neglected agriculture. The question of employment is at the present moment a very press-

ing problem indeed. The 1,065,645 people in the United Kingdom who are under poor relief (1910), the many thousands of men and women we find in large towns and cities without employment, can be well occupied by the introduction of sugar-beet cultivation. If we introduce this gigantic industry in this country we would employ over 160,000 men in our sugar factories, about 200,000 men would find employment in the trades that work in connection with the sugar industry, and another 240,000 men would find additional employment in the fields. Taking it all round, by the work provided by the introduction of the beet-sugar industry 600,000 men would find employment, representing 450,000 families, which at four per family would mean that 1,800,000, equal to 4 per cent. of the whole population, would be interested in the beet-sugar industry. Our position in the world depends upon maintaining a large rural population. We all read the sore and disquieting accounts of the depopulation of different districts in our islands. This ever-increasing exodus, which robs the country of the best healthy working men and women and a sturdy agricultural population and drives them into other countries, where they find more favourable economic conditions and where they work in competition against us, could be stopped. The sugar-beet is most admirably adapted for small holdings. No other crop is so suitable, because sugar-beet can be grown year after year on the same land or with rotation.

To cover our demand for sugar we require five hundred factories to supply us with sugar: each factory would cost 80,000*l.*, so that 40,000,000*l.* might be safely and profitably invested at home. The 25,000,000*l.* sterling we send year by year to foreign countries would remain here, increase our wealth, benefit British agriculture, British trade and commerce, and British capital and labour. The high dividends paid during the last years by most Continental beet-sugar factories show the profitability of this industry. Our export of capital has already reached excessive dimensions. To produce all the sugar we consume we would require about a million acres to be cultivated with beet, which we could easily reclaim from the land that went out of cultivation during the last decade. In the progress of economic thought and study, and mainly through the efforts and zeal of practical British economists, the bounties which have been a menace for over thirty years have been abolished since September 1, 1903. With the introduction of the beet-sugar industry there would go hand in hand the creation of the sugar-engineering industry and the agricultural-implement industry. To give an example of what would be required if we produced all the sugar we consume, I may mention that twelve million tons of beetroot would be necessary, one million tons of coal, 600,000 tons of limestone, 70,000 tons of coke, twenty million bags, four million cases, and an immense quantity of other materials.

MONDAY, SEPTEMBER 4.

Discussion on the Public Finances of Ireland.

(i) *By* Professor C. H. OLDHAM, *B.A.*, *B.L.*

This paper attempted to give an accurate statement of facts, apart from the controversies which the facts have occasioned. Arrears of taxes for 1909-10 were collected in 1910-11, so the present tax-revenue is taken to be the mean of both years. Add non-tax revenue as in 1910-11. We thus get 10,032,000*l.* for the present revenue 'contributed' by Ireland. In 1910-11 the expenditure in Ireland was 11,344,500*l.* Hence Ireland is being run at a loss, which for the moment is 1,312,500*l.* per annum, but which will increase.

The 'contributed' revenue, however, is really not known, and the estimated adjustments, by which the Treasury calculate it, are certainly inaccurate. The 'collected' revenue is accurately known. It is 11,704,500*l.*, at present 360,000*l.* above expenditure. But the steady growth of expenditure will soon obliterate this small margin.

Seventeen years ago Irish taxation was excessive by two and three-quarter millions: for Ireland paid one-eleventh while her 'taxable capacity' was one-twentieth relative to the United Kingdom. To-day she pays one-sixteenth, but her 'taxable capacity' has receded to one-twenty-fifth: so her taxation to-day is excessive by above three millions.

There is nothing in the public finances of Ireland undèr the Union to correlate revenue and expenditure. In 1891-92 State expenditure was 5,985,999*l.* (1*l.* 5*s.* 0¾*d.* per head); in 1910-11 it is 11,344,500*l.* (2*l.* 11*s.* 9¼*d.* per head). The paper gave an analysis accounting for this increase, showing that it arises from new developments of policy, and it will continue.

The present position of Irish finances is characterised by three inequitable features, viz.:—

(1) Great Britain is tributary to Ireland by about a million and a quarter per annum, but the figure is increasing.

(2) Great Britain is also paying Ireland's share of Imperial burdens (Army, Navy, and National Debt): taken at one-fifth of Irish revenue, this share would be about two millions per annum.

(3) Ireland is paying into the common purse an excess payment, beyond her fair proportion measured by 'taxable capacity,' of above three millions per annum.

These evils are endured by both countries in order to maintain expenditure in Ireland at a figure which is, for reasons indicated, about double what it should be. But the present position cannot be understood unless we also keep in view the quite different position in the past. An analysis of 'true' revenue and expenditure in Ireland, made on the basis of Treasury estimates, shows that in the course of one hundred years Ireland, besides paying for Government expenditure in Ireland, has contributed to the British Exchequer a clear net payment of about 330 millions sterling.

On this survey of the facts, each person may draw conclusions for the future. The author submitted that the finances of the Union are to-day equally undesirable to both countries, and that the one sure remedy . . . 'is to put upon the Irish people the duty of levying their own taxes and of providing for their own expenditure' (Lord Farrer, Lord Welby, and Mr. Bertram Currie, 1896).

(ii) *By* A. L. HORNER, *K.C., M.P.*

The findings of the Financial Relations Commission of 1896 being anything but unanimous, no 'financial argument' in favour of Home Rule could be founded then or now upon any of the reports, if, as is alleged (1) Great Britain is tributary to Ireland by 1,250,000*l.* per annum; (2) Great Britain is paying 2,000,000*l.* per annum as Ireland's share of Imperial burdens; and (3) Ireland is paying 3,000,000*l.* per annum beyond her fair proportion; neither Ireland nor Great Britain has any grievance, as the accounts substantially balance.

Since the Act of 1817 consolidating the exchequers of Great Britain and Ireland, the ratio of contribution by Ireland to the Imperial expenditure fixed by the Act of Union ceased, and Great Britain took over the Irish National Debt of 112,000,000*l.* Since 1817 Ireland became fiscally an integral part of the United Kingdom.

'The principle which, under the Act of Union, should now regulate the financial relations between Great Britain and Ireland, and which in practice does regulate them, is that of uniform or indiscriminate taxation subject to such particular exemptions or abatements as the circumstances of Ireland may require.'—Sir D. Barbour (1896).

Any readjustment contemplated in forthcoming legislation must proceed on one of the following three lines:—

(1) Heavier taxation in Ireland, so that she may pay as a minimum for her own Government, exclusive of anything to the army and navy. This is impracticable.

(2) Great reduction in Irish expenditure. It was said 'the Government of Ireland was extravagant as compared with its fiscal resources to a degree exceeding 5,000,000*l.* a year.' But if Ireland is to progress expenditure must

increase. That is also the experience of other Governments. No economies but the reverse are likely in connection with Old Age Pensions, Irish Development Grant, Post Office, Revenue Collection, Local Government, Land Commission, Department of Agriculture, and Education. The expenditure of county councils and municipalities in Ireland has steadily increased since their start.

(3) The British taxpayer should continue to give money for Irish purposes. Ireland's average contribution to the Imperial Exchequer for the past two years was 10,032,000*l*. each year.

But the total Irish expenditure last year was 11,344,500*l*.

Add to this deficit the interest on Ireland's share of the National Debt and a small contribution to Imperial expenses, and a new Parliament must start by providing for a deficit of at least 4,000,000*l*. its first year. This deficit, with growing expenditure in Ireland on Education, Public Works, and General Development, is certain to increase substantially each year. Ireland cannot pay it. Great Britain must pay it, together with much of Ireland's share of Imperial expenses, and also find the money (probably a total of over 200,000,000*l*.) for Land Purchase. At the same time Great Britain would have no control over this deficit. 'A plan so profligate, and so unjust, would not last more than three or four years.'—*Spectator*. Ireland's credit under Home Rule must be small. Her rateable valuation last year was 15,698,530*l*., that of Lancashire being nearly 12,000,000*l*.

The due balance between local and Imperial taxation is important in considering the financial relations between the two countries and Ireland's capacity to bear increased taxation. The net expenditure of Irish local bodies from revenue during last year was 6,844,613*l*., and the local indebtedness was 22,066,834*l*.

The financial provisions of the forthcoming Bill will be viewed with distrust, as no one will know how far the Government's Advisory Committee in their investigations regarded Ireland as a unit for the purposes of taxation, and equally a unit for the purposes of expenditure; nor will it be known what figures were placed before the Committee.

The following Papers were then read:—

1. *How Germany tries to Abolish Poverty and Crime (Extracts from the Official Reports of the Armenpflege of Berlin-Munich-Nuremburg,* 1908–09). *By* Miss CHARLOTTE SMITH-ROSSIE.

This paper consisted principally of official extracts, but some idea of the German *Armenpflege* is essential to understand it. This is a voluntary and unpaid body armed with extraordinary power and having at its command the services of the police and the Minister of the Interior. Its work is partly to relieve poverty, but mostly to prevent it. Its regulations are therefore sometimes startling to us whose Poor Law system is charitable almost entirely. Thus the German Armenpflege does not hesitate to demand repayment of its disbursements, and in the Rhine Provinces even to make this repayment an essential before any marriage can be performed with full civil rights. The marriage is valid in itself, but the 'heimat' or parish rights follow as if it was not valid. It regards the preservation of the home as the chief hope of the reformation of the criminal. It will store furniture of poor people temporarily forced to leave their homes rather than see the home broken up. This is done for persons forced to go into hospitals, and even for criminals of short sentence. Sometimes the rent is paid for similar reasons. The desire to keep up the *home* is at the root of the German law of Aussteuer or dowry—it is to prevent young married couples getting into the trouble caused by furnishing 'on the hire system.' It is declared in the statutes to be 'zur einrichtung des Haushalt' or for the household. This watchfulness over the causes of poverty and crime is at the root of the law which enables the Armenpflege to bring a man before the law courts if he has wasted his substance in a manner likely to impoverish his household. France and Switzerland have also this law, but Britain has not.

The peculiar institutions called variously 'Natural Verpflegungstationen' and

'Häuser für Obdachlose' (that is houses for the shelterless) are homes where respectable working-men in search of work may find shelter without food for a few days or weeks. This is a means of preserving men from the casual ward. It is said that the number of tramps arrested in Austria when she had first copied this system fell about three-fifths from this cause alone. In Sussex the system of 'way' tickets has been adopted, but it is far behind the German plan.

The German laws to protect the 'auscheliche' or 'out-of-marriage' child are a marvel of mercy and wisdom. Germany protects these children by means of the Ladies' Committee of the Armenpflege, to whom the money due from the father is paid by the employer of the man. If the father does not wish to pay, the Armenpflege forces him. The mother is not allowed to spend this money at her own will; the Ladies' 'Verein' watch that it is spent on the child. The child must be properly fed and clothed until it is sixteen, and the father must also pay for it being taught some means of earning a living. If the child is incapacitated by mental or physical weakness, then the father must support it all his life. In England the ratepayers have to do this. This claim on the father does not die with him, but is a claim on any property left by him.

Children (at least under fourteen) cannot be over-worked in Germany. According to our Howard Association the want of open spaces where children can play is a fertile source of juvenile crime. In Germany playgrounds are being formed everywhere, and the streets are hardly used by children in any German city for play. Everything is organised and graded—there are gardens with sand banks for infants, there are Schulerspielplatze for elder children, and there are Spaziergänge and Wanderungen for older ones. These are not free except to the very poor, but the charge is small.

Elaborate efforts are made to stop underfeeding of children: there are 'table scholarships' for the better class and elder scholars, and there are dining-halls in the schools for the very poor and in the cities, where for a small price every child may have a good meal. The mothers are not forgotten, especially when nursing, and for them dining-halls are started where they also hear advice how to train their children. Sterilised milks and other foods are either sold here very cheaply or given gratis.

2. *The Organisation and Development of the Resources of the Empire in the National Interests.* *By* C. Reginald Enock, *F.R.G.S.*

Although the abundant natural resources, at present largely undeveloped, of the British Empire could support all its inhabitants in plenty, there are millions of people in England living in serious insufficiency. Under a system of organisation all these could be made producing and prosperous citizens, and destitution and unemployment gradually eliminated. This organisation would bring about the establishing of new centres of possession and industry, as reciprocal parts of each other, at home and in the Colonies. The producing power of the Empire and the spending power and efficiency of the poorer classes would be increased, and greater social equilibrium brought about. The author submits that the time has come in the history of the world for the inauguration of a new science: that of the organisation of natural resources, and of the human material, and the establishing of the true relationship between them; beginning with the British Empire.

TUESDAY, SEPTEMBER 5.

Discussion on the Arrangement for Reciprocal Trade between Canada and the United States. Opened by C. E. Mallet.

The Problem stated.—The issue before the Canadian people. The general character of the new treaty and the general grounds on which it mended and attacked. The position of Canada; her geography, her

and her markets. The natural lines of her development and the considerations which may alter and affect them. The two ideals—freedom and regulation of trade.

The History of the Movement towards Reciprocity.—The establishment of Free Trade in England in 1846 is followed by irritation and protests in Canada, and leads to a policy of closer intercourse with the United States, culminating in the Elgin-Marcy treaty of 1854. This treaty results in a great increase of Canadian trade, especially during the American Civil War; but dissatisfaction in the United States and political friction terminate the treaty in 1866. Reciprocity continues, however, to be an object with Canadian statesmen; Canada makes repeated efforts to revive it between 1866 and 1878; and it long continues to be the aim of large classes and interests in the Dominion.

The Movement towards a 'National' Policy.—Meanwhile a different ideal of trade policy asserts itself, beginning in 1858 and 1859 with the Tariff measures of Cayley and Galt. This gains ground after Confederation, triumphs decisively in the General Election of 1878, and results in the National Policy of 1879-1896. This policy, although repudiated by the Liberals in opposition, is in fact adopted and extended by them on their accession to power, and remains from 1897 to 1907 the ruling influence in Canadian trade. A preference to Great Britain is, however, combined with it, which is raised in 1900 to 33⅓ per cent., but which is afterwards modified and limited in 1904 and in the Tariff revision of 1906-07.

The Working of the British Preference.—The object and the value of preference. Its advantages for British manufacturers and for Canadian consumers; but its inevitable disadvantages for protected Canadian interests. The general question of colonial preference; what it involves; the British side. The difficulty of making preference effective; limitations even in the Canadian case. The inevitable dilemma involved in all efforts to reconcile preference with protection.

The Results of the National Policy two-fold.—The stimulus given by protection to manufacturing interests in Canada. The growth of tariffs and the claims of the interests affected; the favourites of protection—soap, sugar, iron and steel, and others; the 'Red Parlour' politicians. The organisation of trusts and their rapid development. Large combines and their profits. Influence of the Press. Concentration of power in the hands of a limited number of ruling interests. The other side of the policy; the unorganised interests suffer. Decrease in the number of manufacturing establishments and in many cases of the hands employed. Limitations on production; decline in some great exports; doubts whether the tariff, while building up certain wealthy interests, is developing Canadian resources to the best advantage; significant figures. The unprotected interests and their grounds of complaint. The cost of living and the rise in prices. The position of the workman; the position of the farmer; the handicap imposed by the tariff on the farming, the mining, and the fishing industries. The revolt of the West. The revival of reciprocity as an active force in Canadian politics.

The Meaning of the Treaty.—Fears aroused by the new treaty; their slight foundation. The manufacturing interests in Canada; their organised strength the rights of the community against them. British interests; will they suffer? An examination of the effects of the treaty on British preference, British industry and the British food-supply, shows no grounds for serious apprehension. Any measure which helps the natural development of Canada is a source of Imperial strength. Apart from that, Canada is entitled to arrange her fiscal system for herself. Larger issues involved in the problem; the dangers of unnatural restriction; the meaning and the value of freedom.

Discussion on Methods of settling Industrial Disputes. Opened by

Hon. Samuel Mauger.

The following Paper was then read :—

A Positive Method of Economic Inquiry. *By* EWART SCOTT GROGAN.

The evolutionary stages of all inquisitive method may be differentiated as belonging either to the Anthropocentric era or to the Heliocentric era of human thought. Contention that economic 'orthodoxy' is a survival of the Anthropocentric era, and that definite emergence into the Heliocentric era of economic inquiry requires a positive method. Positive method requires a qualitatively constant nucleus of relation and a qualitatively constant nexus of relation. Destructive criticism of economic 'orthodoxy' with 'value' as its nucleus and 'labour' as its nexus of economic relation. Constructive problem of a positive method. A possible task, because subject-matter of inquiry is exclusively physical, though extreme complexity restricts useful sphere of inquiry to broad generalisations.

Constructive problem involves :—

1. Analytical determination of the required nucleus and nexus of economic relation: 'Food-energy' the nexus of economic relation; 'Sun-frontage' the nucleus of economic relation.
2. Synthetical determination of economic law: The dominant economic law; 'the well-being of a community varies inversely with the proportion of its energies absorbed in its essential food-production and in greater proportion.' A derivative economic law; 'the well-being of a community varies with the extent of land which it effectively controls by actual occupation or by access through free exchange and in greater proportion.'

Section G.—ENGINEERING.

President of the Section.—Professor J. H. Biles, LL.D., D.Sc., M.Inst.C.E.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

During recent years accidents have happened to ships and they have mysteriously disappeared. The complete disappearance without leaving any trace has led to the assumption that the vessel has capsized. The circumstances of such cases obviously preclude the existence of any direct evidence. The only subjects of investigation can be (1) the condition of the ship prior to the accident, and (2) the probability that such a condition could be one which in any *known possible circumstances* could lead to disaster. The first is determinable by evidence in any particular case. The second involves a consideration of the whole question of the behaviour of ships at sea. What is the effect upon any given ship of a known series of waves? What waves is a ship likely to meet?

This subject has occupied the attention of scientific engineers, and it may be said to have been considered a solved problem. We have thought that if a ship has a certain metacentric height and a certain range of positive stability she is quite safe from the action of a series of waves of any kind which we know to exist. If, however, a known ship (and perhaps more than one) has these safety-ensuring qualities and mysteriously disappears, it may be desirable to review the grounds of our belief to see whether any *known possible combination* of circumstances may cause disaster.

Let us then first briefly review the grounds of our belief. Fifty years ago Mr. Wm. Froude showed that the large angles occasionally reached in rolling are not due to a single wave-impulse, but are the cumulative effect of the operation of successive waves. The period T of a small double oscillation of a ship in water free from wave disturbance and resistance is $2\pi\sqrt{\frac{k^2}{gh}}$, where k is the radius of gyration and h is the metacentric height (*i.e.*, the height of the metacentre above the centre of gravity). The period T_1 of a wave is $\sqrt{\frac{2\pi l}{g}}$, where l is the length of the wave from crest to crest and g is the acceleration due to gravity. The line of action of the resultant of the supporting pressures acting on a ship in undisturbed water is the vertical through the centre of gravity of the volume of the water displaced by the ship. In wave-water it is in the normal to the effective wave-slope (which is approximately the wave-surface). The oscillation of this normal as the waves pass causes a varying couple tending to incline the vessel. If the vessel is very quickly inclined by this couple she will place herself in or near the normal and the inclining couple will be of zero value. If, however, her movements are very slow, the normal may make one or more oscillations before any appreciable effect is produced on the vessel. The tendency to incline in one direction caused by the normal acting on one side of the vertical is checked by the rapid oscillation of the normal to the other side of the vertical. It is, therefore, evident that the

relation between the period of the ship and that of the wave normal is a dominating feature in the resulting movement of the ship. Mr. W. Froude's mathematical solution of this relation is the basis of our belief that we understand the behaviour of a ship in the *uniform* system of waves when the vessel is placed broadside on to the waves. To obtain this solution he *assumed that within the limits considered, the moment of stability varied as the angle of inclination.* In the curve of righting levers of a ship, usually known as a curve of stability, this condition holds generally for angles up to about 10°. The curve usually reaches a maximum value at about 30° to 40° and vanishes at 60° to 80°, so that for large angles of roll the assumption does not hold. On this assumption, however, he showed that the motion of a ship amongst such a system of waves is the same as for still water *plus* a motion composed of two sine terms. The amplitude of this latter motion depends upon the maximum slope of the waves and the ratio $\frac{T}{T_1}$ (the period of the ship in undisturbed water to the period of the wave). If the ship starts from rest in the upright, θ is the maximum angle of inclination of the ship and θ_1 the maximum wave-slope; then

$$\theta = \theta_1 \cdot \frac{1}{1-\frac{T^2}{T_1^2}}$$

He considered several solutions of the equation of motion :—

(1) $T=T_1$; this is synchronism, and the angle of inclination gradually increases. Each wave-impulse adds something to the ship's inclination, and *without any resistance to rolling* the vessel would capsize.

(2) $\frac{T}{T_1} = 0$; this is the case of the ship's period being very small compared with that of the wave. θ will then be positive and equal to θ_1. In other words, the ship will place herself normally to the wave-slope. The maximum amplitude will only be the maximum wave-slope.

(3) $\frac{T}{T_1} < 1$. In this case the wave-period is greater than that of the ship and θ is always positive and greater than θ_1. The vessel always inclines away from the wave-slope. If

$$\frac{T}{T_1} = \frac{1}{4},\ \theta = \frac{16}{15}\theta_1.\quad \text{If } \frac{T}{T_1} = \frac{1}{2},\ \theta = \frac{4}{3}\theta_1.\quad \text{If } \frac{T}{T_1} = \frac{3}{4},\ \theta = \frac{16}{7}\theta_1$$

The nearer $\frac{T}{T_1}$ is to unity the larger is the maximum amplitude.

(4) $\frac{T}{T_1} > 1$. In this case the wave-period is less than that of the ship, and θ is always negative. The vessel inclines towards the wave-slope.

$$\text{If } \frac{T}{T_1} = 1{\cdot}1, \text{ then } \theta = -4{\cdot}70\,\theta_1;$$

$$\frac{T}{T_1} = 1{\cdot}26, \text{ then } \theta = -\theta_1;$$

$$\frac{T}{T_1} = 2{\cdot}0, \text{ then } \theta = \frac{1}{3}\theta_1;$$

$$\frac{T}{T_1} = 2{\cdot}235, \text{ then } \theta = \tfrac{1}{4}\theta_1.$$

This shows the advantage of having T greater than T_1.

The ship goes through a cycle of changes of extreme angle of roll. Mr. W. Froude considered the effect of variations of $\frac{T}{T_1}$ upon these cycles. $\frac{T}{T_1} = \frac{5}{4}$ is better than $\frac{T}{T_1} = \frac{4}{5}$, so that it is better to lengthen T than to shorten it. Similar results for $\frac{T}{T_1} = 2$ and $\frac{1}{2}$ respectively gave better results by lengthening than shortening T. In each of

the cases $\frac{T}{T_1} = \frac{5}{9}$ and $\frac{T}{T_1} = \frac{9}{5}$ the results show *baulked oscillations* in which, while the vessel swings towards the vertical, she does not reach it but swings back again. The lengthened value of T here also gave better results than for shortening it.

The results given above are greater than would be obtained in practice, because *resistance has been neglected*. Later he determined the effect of resistance upon rolling in still water free from waves. He determined the law of resistance and found it to vary partly as the angular velocity and partly as the square of it. He rolled a ship, and after she was allowed to roll free from disturbance he measured the angle of inclination at the end of each roll. These showed the rate of extinction of the rolling due to the resistance. The loss of extreme angle of roll between one roll and the next represented the work done by the ship in rolling. It is possible to calculate the work done in inclining the vessel to any angle, and the difference between the amount of work thus done in two different angles represents the difference in work necessary and therefore work done in resistance to bring the ship to these angles of inclination. Hence the work done by resistance between two consecutive rolls can be actually measured by measuring the extreme angle of inclination in successive rolls.

Having determined the resistance in terms of angles of roll and time, it was easy to determine the law which represented the resistance in terms of the angular velocity.

In applying this to waves, all that is necessary is to take account of the fact that the position of equilibrium about which the ship oscillates is the normal to the effective wave-slope. This normal has a definite oscillation about a fixed vertical. It is, therefore, possible to determine the angle of inclination in terms of time.

As these angles of roll may be considerable, the assumption upon which the general solutions for *unresisted rolling*, already given, were based will not hold. The actual moments of stability depend upon the form of the ship and the position of its centre of gravity, and as these vary in different ships it is only possible to obtain the relation between inclination and time by a special investigation in each case. A solution by a method of graphic integration was devised by Mr. W. Froude and has been applied to a very small number of cases. The information necessary to obtain a solution in any one case is as follows :—

(1) A curve of righting levers in terms of angle of inclination. This is called a curve of statical stability.

(2) The form and period of the wave on which the ship is supposed to be placed broadside on.

(3) The constants which determine the actual value of the resistance moment in terms of the angular velocity. These can be obtained by rolling the ship in still water and observing the rate of extinction of rolling when that extinction is due to resistance only. The form of the curve of extinction can be obtained by rolling a model of the ship, but the actual ordinates of the curve for an actual ship can only be obtained by experiment on the ship herself, or by inference from a similar ship of approximately the same size, form, and arrangements.

A consideration of these three necessities for the solution of one particular case shows that a considerable amount of work is necessary for determining the angle of inclination in terms of time. In waves even this solution can only be made for one assumed maximum angle of inclination as a starting condition. For instance, in any case where a ship is assumed to start with a maximum inclination of 20° it is only possible to obtain one solution of angles of inclination in terms of time. If we take another maximum angle of inclination, another complete solution is necessary. The work of each solution is considerable.

For ships which vary much in draught and condition of loading it is evident that for each ship the work of complete investigation for all the conditions of loading of different waves and different angles of maximum inclination is very great. For this reason the investigation of rolling by the Froude graphic method has only been made for a very small number of cases, and our knowledge of the actual angles of inclination of ships obtained by this method is very small.

The curve of statical stability is worked out for many ships in a few conditions of draught and position of centre of gravity. These curves are of little practical value, because they only serve as comparisons between ships. It is assumed that if a ship has a fair range of statical stability, *i.e.*, that the angle of vanishing statical stability

is not less than, say, 60°, and the maximum righting lever is not unlike some previous ship which 'has been to sea and come home again' safely, this ship will be safe. This assumption is based on the belief that only what has happened to previous ships will happen to the one in question; that is, that the contingencies of waves will be the same in all cases. But when we find that occasionally ships are missing we are compelled to ask ourselves the question—is it possible that some occasional contingencies of sea or ship, or both, may exist which will produce a dangerous and perhaps fatal roll?

Mr. W. Froude's investigations were made for a uniform system of waves. He showed that in *unresisted* rolling if a ship initially at rest and in the upright position is acted upon by a uniform series of waves such that $\frac{T}{T_1} = \frac{p}{q}$; where p and q are the smallest whole numbers which express this ratio, then the rolling of the ship will be in cycles, the maximum inclination in each roll gradually increasing, and again gradually diminishing, and so on. The period of occurrence of the maximum of maxima will be $2\,q\,T$. The number of times the ship passes through the upright in each complete cycle is $2\,p$ or $2\,q$, whichever is the smaller. The ship is upright at the middle of the cycle, and on either side of this middle there is an equal maximum which is approximately $\theta_1 \frac{q}{q-p}$, and never exceeds this value (where θ_1 is maximum wave-slope). If T is much larger than T_1, and therefore p is much larger than q, then the value of $\theta_1 \frac{q}{q-p}$ approaches $\theta_1 \frac{q}{p}$ and is less than the wave-slope. If T is much smaller than T_1, then the value of $\theta_1 \frac{q}{q-p}$ approaches θ_1. If T is nearly equal to T_1, then $\theta_1 \frac{q}{q-p}$ approaches a high value.

From this it is seen that our investigations in *unresisted* rolling may be over a very wide field, but would produce no definite result in the matter of finding cases of large angles of roll in practice. We can only obtain valuable results when resistance is included.

Mr. R. E. Froude in 1896 was led to deal with the subject of non-uniform rolling of ships in an assumed uniform system of waves which did not synchronise with the ship, such as is dealt with above for *unresisted* rolling, and he dealt with the effect of resistance in such a case. He pointed out that there is a particular phase-relation between the ship and the wave which will produce uniform rolling, just as there is in the case of a synchronous system of waves. If at any stage for any reason the rolling is of the cyclic character considered in *non-resisted* rolling, then the *resistance must gradually introduce uniformity*, because the rolling is made up of two sets of oscillations—

(1) That due to the rolling relatively to the water surface, such as would occur in undisturbed water.

(2) That due to the oscillation of the water-surface itself, caused by the passage of the wave.

We have already seen that the *resisted* oscillation in undisturbed water gradually decreases when the vessel is left free to oscillate, but takes place in practically uniform time T. The oscillation of the water-surface is *forced on the ship* and causes a simple harmonic oscillation of the ship in time T_1 in algebraic addition to that due to the free resisted oscillation. When the maximum angle of a roll due to the free oscillation coincides with the maximum angle due to the forced oscillation of the wave, we shall have a maximum extreme inclination which is the sum of that due to the free and the forced. When they are in opposition we shall have a minimum extreme oscillation which is the difference of these two. At stages between coincidence and opposition we shall have extreme angles varying between maximum and minimum. As time goes on the extreme angle due to the free oscillation gradually decreases under resistance, and the sum and the difference referred to above approximate to each other, and the rolling becomes that due to the wave alone. We have seen that in the case of unresisted rolling where the wave and the ship synchronise there is an addition to the angle of inclination for each passage of the wave, and were it not for resistance these accumulated increases would cause the vessel to upset. But in the

case of resisted rolling each increase of extreme angle of roll causes an increase in the work done upon the resistance of the ship, and when the increase in work done in increasing the angle of heel by each passage of the wave equals the work done in increasing the resistance incurred in swinging through this greater angle, then we shall have a balance of condition and a uniform angle of roll. The angle at which this balance takes place depends on the period and maximum slope of the wave and the coefficients of resistance between the ship and the water. For instance, with a maximum wave-slope of 3° and with a ratio of ship to wave-period of 1·1 the value of the angle of ultimate uniform rolling in the case of H.M.S. *Revenge* was found to be 13°·9 without bilge-keels and 10°·8 with them. In the case of synchronism of the ship and the wave, the rolling is uniform always and reaches a maximum of 41°·1 without and 14°·85 with bilge-keels. The nearer the wave and ship are to synchronism, the larger is the maximum inclination reached before uniform rolling sets in and during uniform rolling. Resistance is of much more importance in the case of synchronism. If the ratio of ship to wave-period be 1·3, the maximum angle before uniform rolling is reached is 8°·25 without and 6°·6 with bilge-keels, while that due to uniform rolling is 4°·35 without and 4°·24 with. We see, therefore, the important part that the near approach to synchronism plays in creating large angles of roll and the value of bilge-keels in reducing the rolling in conditions approaching synchronism. When on waves of smaller period, when small angles of roll may be expected, the bilge-keels give but small advantage. *The assumption in these cases* is that the vessel starts from *rest in the upright in the mid-height of the wave*, and that the rolling is caused by the assumed uniform swell. The vessel will go through the cyclic change already described and will reach a maximum inclination of not more than double that which she reaches when uniform rolling has set in.

A later investigator, Colonel Russo of the Italian Navy, *found by experiment* that by *varying* the assumption as to starting condition of the ship, by letting the wave-action begin to operate first *when the vessel is upright and at rest on the crest of the wave*, the maximum angle before uniform rolling sets in can be more than four times that due to uniform rolling if the time of the ship is greater than that of the swell. There is an infinite number of solutions of rolling amongst waves because there is an infinite number of initial circumstances, but, whatever these may be, the rolling in a uniform swell will always soon degenerate into a series of uniform forced oscillations in the wave-period.

From this discovery of Colonel Russo's we see that the region of investigation of *possible causes of upsetting* is removed from that of uniform rolling even in a non-synchronous sea. The following table shows for the *Revenge* with bilge-keels the variation in maximum angle of inclination before and during uniform rolling in terms of the period and length of the swell:—

Period of swell in seconds . .	8	10	12	13·3	15	17	19
Length of swell in feet . . .	328	512	738	910	1153	1481	1850
Maximum angle in degrees before uniform rolling	6·3	8·0	14·7	21·4	17·1	13·0	11·0
Maximum angle in degrees during uniform rolling	2·5	4·2	12·6	21·4	15·4	11·0	8·7

The period of free rolling of the *Revenge* through small angles for a double roll was about 16 seconds. The foregoing shows that the maximum rolling (which occurs at synchronism) took place at a period of swell of 13·3 seconds. The period of roll was less at large than small oscillations. The above figures are for waves varying from $\frac{1}{37}$th to $\frac{1}{74}$th of their length in height. The length of wave which corresponds to maximum inclination is 910 feet and height is about one-fiftieth. The maximum wave-slope for such waves is 3°·6. We are in the habit of dealing with waves of one-twentieth of their length in height for strength calculations. Observers have recorded waves in the open ocean of 600 to 800 feet in length and of 30 to 45 feet in height, so that we know that the slope of the waves assumed by Colonel Russo is much less than may be encountered at sea. A wave whose length is twenty times its height has a maximum slope of 9°. Records of waves having a ratio of height to length of as great as one-thirteenth have been published. The maximum slope of wave corresponding to these proportions is 14°. If it is admissible to take much larger angles of wave-slope we may expect to get much larger angles of maximum inclination both before uniform rolling sets in and when it does. In a case given by Mr. Froude in which the maximum inclination in the *Revenge* before uniform rolling was

·12°, he showed by calculation that the corresponding maximum wave-slope must have been 5°·09. For 20° maximum inclination the wave-slope was 10°·3. Both these cases were for periods of ship and wave of 16 and 13 seconds respectively. For similar periods of 16 and 14·6 seconds the wave-slope to produce 20° maximum before uniform rolling is only 7°. These figures give some idea of the effect of the wave-slope on the maximum inclination. It is to be remembered that these are the maximum angles obtained by Mr. Froude; but if we take Colonel Russo's maximum angles, which in some cases are double those obtained by Mr. Froude, it is easy to see that large wave-slopes may produce very large angles of roll.

Summarising, we see that:—

(1) With wave-slopes of 3°·6 the angles of maximum roll obtained in the *Revenge* with bilge-keels may be taken at 22°.

(2) This roll takes place when synchronism exists between the wave and the ship, when the wave is 910 feet long and 18¼ feet high and has a wave-slope of 3°·6.

(3) Waves exist which are of this length, but which may have a height of 50 feet, and possibly more, and a wave-slope of 10°.

(4) In such steeper waves we should expect to get much larger angles of roll.

(5) Each ship has peculiarities of rolling due to its form as well as to its lading and bilge-keels, &c.

(6) These peculiarities and the effect they have upon rolling, and the effect different waves will have upon the rolling of the ship, can best be studied experimentally.

It was my intention when you appointed me as your President to have placed before you the results of an experimental study made on lines somewhat similar to those carried out by Colonel Russo, but extended to a wide range of types of ship, waves, and resistance.

The machine for carrying out these experiments is practically complete, but having met with an accident at the end of April last which incapacitated me for some time I was prevented from being able to do anything to this subject since then. I am, therefore, obliged to ask you to be content with the general *résumé* of the subject which has been given.

I think enough has been said to show what a field of investigation is open to the experimenter. The little that has been done and published by Colonel Russo is only for three battleships of about the same size. For the great bulk of the ocean wayfarers nothing has been done. If it is possible to determine the kind of rolling which is likely to take place under stated conditions it seems to be desirable to do so.

In all that has been said it will be seen that it is possible to determine experimentally the kind of rolling which will take place in a ship which is snug and seaworthy. But it is also possible to study the effect of loose water in a ship under the same set of conditions as to waves, lading, and form of ship. This part of the subject has not received any experimental treatment except in a very limited number of full-sized ships. It is quite conceivable that some conditions of loose water associated with some conditions of sea may produce large angles of inclination.

The subject has been treated as one in which it is probable that the kind of waves met with at sea will be uniform in size and period. That this is not so is a fact with which we are all more or less familiar. The effect of a uniform system of waves is rapidly to induce a condition of uniform rolling. But any deviation from uniformity of sea immediately introduces non-uniformity of rolling, and generally greater extreme angles of roll. Any experimental study of the action of waves upon a ship must include a variation in the character of the waves. The field of investigation is thereby widened and the search for large angles of inclination made more laborious. But the work is of a kind which can be done by many people, and can be done fairly rapidly, so that there seems to be no insuperable objection to doing it. The details of the apparatus need not be described, but the study of the objects attained may be of interest.

(1) Wave-motion is simulated by the revolution about parallel axes of two parallel cranks of different lengths. The line joining the ends of the arms of the cranks is always in the line of the normal to the wave-surface, and a line perpendicular to it is therefore parallel to the wave-surface.

(2) From the form of the ship are determined curves which are the shape of rollers which roll on a straight line parallel to the wave-surface. The form of these rollers is such that the model of the ship in rolling maintains the position in relation to the wave-surface (*a*) which cuts off constant volume of displacement at any angle of incline-

tion; (*b*) in which the perpendicular to the straight line parallel to the wave-surface through the point of contact is the line of the resultant of the water-pressures acting on the vessel.

(3) The resistance to rolling is obtained by (*a*) electro-magnets, the current to which is generated by the motion of the model, (*b*) secondary electro-magnet, the current for which is in the first magnet. (*a*) represents the resistance due to the angular velocity, (*b*) represents the square of that velocity.

The variations in the lengths of the cranks and the speed of revolution give the variation in the wave-form assumed. The variation in the electric current by resistances in the circuit gives the variation in the resistances to rolling of the ship. For instance, the current necessary to represent the resistance of a ship with bilge-keels is very different from that for one without.

It is hoped that sufficient has been said to call attention to the possibility of extended study of the rolling of ships at sea, so that some valuable work may be done in this important subject.

The following Papers were then read: –

1. *The Origin and Production of Corrugation of Tramway Rails.*[1]

By W. WORBY BEAUMONT, *M.Inst.C.E.*

The explanation of the presentation of this paper on a subject previously discussed in a brief paper by the author before the Association in 1907 is the fact that, although the serious increase of corrugation since that date has caused much trouble, expense, and public annoyance, the real cause of corrugation has not been recognised. One and the chief reason for this is the fact that corrugation can only be prevented by calling halt in the direction in which tram-car design has increasingly tended in recent times. Great weight on small wheels at high speeds means a combination which is destructive to any permanent-way which, as a tramway or street railway, can be made with any known materials and used on the common highway. As an abstract of the paper which the author now presents, he repeats and supplements the salient points appealed to in his explanation of the causes and production of corrugation as previously outlined, and this he does with a full knowledge of the numerous writings and experiments on the subject by the authors of papers on the subject and of inquiries by home and Continental bodies troubled by this engineering ailment.

Although the physical and mechanical conditions involved in the origin of corrugation are complex, the mode of operation of the causes is simple, and for an explanation simple phenomena of known recurrence and adaptation in engineering works may be appealed to for this purpose. When a piece of cold iron or steel is subjected to pressure exceeding the limit of elastic compression by a rolling or hammering action, or by these combined, the result is spreading of the material and change of the dimensions. The hammering or rolling work done upon a surface tends to compress the material beneath it; but being nearly incompressible and unchangeable in density, the material flows, and change of form results.

Generally the material thus changed in form suffers permanently no greater stresses than those within its elastic limit of compression or extension. When, however, the material is not free to flow or change its form in the direction in which the stresses set up would act, the effect of continued work done on the surface is the growth of compressive stress exceeding elastic resistance.

In railway rails the freedom for the flow of the material is limited. Hardening of the surface takes place, and destructive compression of the surface material is set up. If the material be cast iron the destructive compression causes crumbling of the superficies, and the consequent relief of the material immediately below from stress beyond that of elastic compression; but when the material is that of steel rails crumbling is delayed by its greater elastic extensibility and toughness, the upper part near the surface being under intense compression, differentiating from a maximum at the surface.

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[1] Published in full in *Engineering, The Electrician,* and *The Electrical Review,* September 8, 1911.

The repeated running of the heavily laden tramcar wheel over the rail does thus gradually compress the surface of the crown of the rail. Of this stress transversely the material relieves itself partially by the detrusion at the edges of the rail, where it forms a lip on the outside or on the groove side, or on both. This lip remains on the outside of the rail, but is worn off on the inside by the wheel flange. In the longitudinal direction the stresses arising from the compression of the surface material are not thus relieved. Areas of maximum compression are thus originated round points separated by distances which are determined mainly by the relation between compression resistance and elastic tensile strength of the material rolled, but in part by the relative hardness of the roller and rail and by the mechanical conditions which affect the area of the rail and roll contact. The heavily laden tramcar wheel presses into the surface of the rail, and as it rolls along presses before it a wave of compression the translation of which involves the destructive rupture of the surface or the rise of the wheel over the minute crest of the wave. The result is the formation of an extremely hard surface in patches of various shapes and lengths, and separated by distances depending on several conditions, including the mechanical properties of the rail, its combined hardness and toughness. Where the bright hard patches alternate with an approach to regularity with the dull and rougher surface patches the result is known as corrugation. This character of surface may be found on every heavily worked tramway under conditions of such impartial contrariety that it may be ascribed to conditions of origin which are general.

The remedy appears to be: (1) lighter cars; (2) larger wheels; (3) harder rails; (4) moderate speeds.

2. *Anschutz Gyro-Compass.* *By* G. K. B. Elphinstone.

This apparatus is a compass in the true sense of the word; that is to say, it takes up a definite direction on any part of the earth's surface, so that its axle points to the true north and south, or is, in other words, parallel with the meridian. This position is arrived at automatically no matter in what position the compass is started.

The apparatus consists of a rapidly rotating gyrostat enclosed in a casing so suspended that the centre of gravity of the whole system is considerably below the point of suspension, and on that account the system is acted upon by gravity like a pendulum. The action of gravity is such as to keep the axle of the rotating gyro always horizontal.

When the axle of the gyro is pointing in any direction except parallel to the meridian the gyro-wheel tends to maintain its plane of rotation fixed in space, irrespective of the rotation of the earth, and the rotation of the earth would merely carry round the gyro with its plane of rotation remaining parallel to its original plane.

Under these conditions one end of the axle would dip down from the horizontal or tangential position on the surface of the globe, and the other end would incline upwards. This tendency, however, is opposed by the force of gravity acting as described above, and there follows a precession turning the axle towards the meridian, this precession continuing until the effect of gravity has caused the axle to become horizontal once more.

Should this condition be reached after the gyro-axle has crossed the meridian, the further rotation of the earth will cause a reversal of the inclination of the axle from the horizontal or tangential position on the globe, and on that account the precession will be reversed.

From the above it follows that the axle of the gyrostat would oscillate to and fro across the meridian, the only cause for these oscillations to cease being the friction of the suspension. In order that the system may take up a definite position with good precision this friction has to be very small in amount, and therefore the swinging to and fro would continue for a very long period of time. To get over this difficulty a method of damping these swings without the introduction of friction is required. This is obtained by making use of the current of air set in motion by the rapidly revolving wheel.

This current of air is led out through a horizontal tube at the lowest part of the gyro casing and tangential to its periphery; the air blast acts horizontally.

When the gyro-axle is horizontal—that is to say, when precession in any one direction has ceased—the air-blast is symmetrically situated as regards the vertical line through the suspended system, and on this account the air blast may be considered as divided into two blasts, equal in speed and volume and distance from the centre line, and under such conditions there is no tendency for the reaction of the still air to cause any movement of the gyro-casing other than a slight swinging of the suspended system in a plane coincident with the plane of rotation of the gyro. If, however, the axis of the gyro is inclined from the horizontal position, which is the case whenever the gyro is precessing, and therefore not coinciding with the meridian, then the outlet of the air current is tilted to one side of the centre line, and the reaction caused thereby is in such a direction as to apply a turning moment about the vertical axis of the suspended system, and under the influence of this turning moment a precession of the gyro-axle takes place vertically in such a direction as to bring the axis once more horizontal.

FRIDAY, SEPTEMBER 1.

The following Papers and Report were read :—

1. *On Electric Drives for Screw Propellers. By* H. A. MAVOR.

The problems of marine engineering have until recent years been solved by the application of various forms of the reciprocating steam engine, and the form, power, speed, and general arrangement of power-driven vessels have been developed in connection with this means of propulsion. The advent of the steam turbine and more recently of the explosive type of reciprocating engine has opened up new lines of development, and in certain departments there is evidence that these lines involve the use of intermediate devices between the power-producing and the power-absorbing elements of the machinery. The necessity for these devices arises when the properties of the propeller in respect to the best rate of revolution for the highest economy are incompatible with the same conditions as applied to the requirements emerging from the power generator. The divergence in these properties may be very small or it may be very great. If the divergence be small, there is generally little or no advantage in respect of fuel economy to be gained by the interposition of a transmission arrangement, with its necessary mechanical or other losses; but even in such cases it may be that the transmission arrangement otherwise unnecessary may provide means of dealing with requirements which the steam turbine or internal-combustion engine are incapable of meeting. For example very rapid manœuvring at full power requires in the case of the steam turbine a separate or partially separate reversing equipment, and in the case of the explosive internal-combustion engine the most convenient device hitherto produced is the one of compressed air in the working cylinders for producing the required changes in the direction of motion.

It is to be understood that there are many cases where the intervention of a transmission arrangement does not appear to offer any advantage in fuel economy. The limitations imposed upon the designer by the beam and draught of the ship and the weight to be carried may altogether exclude the use of the transmission devices and necessitate the direct application of the power to the work. For example, in high-speed shallow-draught vessels, or in vessels where the speed is high relatively to the dimensions of the ship, the sacrifice in economy by running at a high rate of revolution is not so great as to warrant the introduction of any intermediate gear which would increase the weight of the vessel and therefore the power to drive her.

Some suggestions have been made from time to time for applying transmission arrangements to vessels of the type of the *Lusitania* and *Mauretania*, but these are not in the opinion of the present writer by any means favourable cases for transmission arrangements.

The advantages of electric transmission over other competing methods may be

most concisely stated by pointing out the deficiencies of the other two methods as compared with the electrical. In the case of the mechanical transmission by the tooth-gear which has been carried out by the Parsons Marine Steam Turbine Company and by the Westinghouse Company in America the results at sea appear to be quite satisfactory, but we are still left with the necessity of providing a reversing turbine, and while there are means of connecting two separate units to the same shaft frequent and sudden reversal of motion of the propeller by means of the reversing turbines would probably disturb the satisfactory running condition of the gear, so that while it has been demonstrated to be suited for long-distance runs it remains to be proved that it will stand the rough-and-tumble service of a vessel where there is much 'backing and filling' to do. In weight, price, and economy the mechanical transmission-gear appears to show no advantage over the electric gear, as the same economy and weight per shaft horse-power can be guaranteed for the electric transmission as is claimed for the mechanical gear transmission. This arises from the fact that the gear ratio can be made higher.

The other competitor is the Fottinger hydraulic transmission, an interesting and ingenious proposition. It has one apparent advantage over the mechanical gear, viz., that it is less rigid in its character, but it is not so flexible as the electric transmission, and it also lacks the possibility of convenient application or withdrawal of individual units, although it might be developed in this respect. The efficiency claimed for it is as high as can be attained by electrical means. The costs and weights are not known to the author, but the experience of transmission with high-pressure water is not uniformly encouraging, and for an equal range of adaptation it appears certain that the electric transmission will be cheaper and more efficient, and the convenience in manœuvring is entirely in favour of the electric gear.

To show that the advantages claimed for the electric gear can be realised in practice a vessel has been built and experimental trials and demonstrations have taken place in the presence of the leading shipowners and shipbuilders on the Clyde. The author believes he is justified in claiming that he has proved that the claims made as to convenience and rapidity of manœuvring and the practicability of the whole arrangement have been fully demonstrated. The actual economy to be gained is a question of study of individual cases. Many of these have been gone into, and although in some it has been found that there is no room for electric transmission, others seem to offer conditions favourable to the use of the electric arrangement, which has always against it the handicap of additional cost and usually of additional weight. It has therefore to win its way against an initial disadvantage which is rather hard to overcome, but the indications are that the ultimate advantages in many instances are such as to warrant the additional expenditure in view of the economy to be gained.

Drawings and photographs of the experimental vessel, and also general arrangement of equipments which have been designed and compared with the normal equipments for the same vessels, were shown.

2. *Electrical Steering.* *By* B. P. HAIGH, *B.Sc., Assoc.M.Inst.C.E.*

Electrical steering offers considerable advantages for steamers as well as for vessels propelled by internal-combustion engines, for the improved economy corresponds to a saving of weight in boilers and fuel. Difficulty has been experienced in obtaining a reliable system of control, capable of dealing with the power necessary to put the helm hard over in emergency in the shortest possible time, and possessing sufficient sensitiveness to enable an accurate course to be kept by moving the rudder promptly in small angles. Sensitiveness is shown by absence of 'time lag' between the movement of the hand-wheel and the corresponding movement of the rudder, and in this respect electrical gears promise an improvement on steam gears, whose economy is reduced when large control valves are fitted. Sensitiveness also requires an absence of undue 'idle travel' of the hand-wheel, but a certain small amount is nevertheless desirable. The steering motor may be started and stopped for every motion of the rudder, but it is preferably kept running continuously, mechanical control being introduced either in the form of hydraulic transmission or in the form of magnetic clutches as

developed by the writer of this paper. In the latter type of gear two magnetic clutches are employed, these being fitted at opposite ends of the motor; and, as no gearing is kept continuously in motion, the wear and tear, as well as the current required, are reduced to a minimum. The clutches prevent the shock of the sea being transmitted to the electrical system, and as they have considerable flywheel effect, the current taken by the motor does not fluctuate widely under normal conditions, and the steering gear may therefore be supplied from the ship's lighting generator. To economise power it is advantageous to arrange the gear so that greater leverage is obtained when the rudder is hard over than when amidships, and by doubling the leverage in this manner a saving of 30 per cent. may be made in the motor power. Drawings were shown of a steering gear suitable for an 11½-inch rudder-post, and of a smaller gear of the same type, built by Messrs. Brown Brothers & Co., Ltd., of Rosebank, Edinburgh, suitable for a 7-inch post. When tested against an artificial hydraulic load the latter gear developed a torque of 50 foot tons at the rudder-post and showed an efficiency of over 50 per cent, at half load. It was found capable of moving the tiller through 70° in 25 seconds and responded to motions of the hand-wheel equivalent to 1° of helm.

3. *The Single-phase Repulsion Motor.*

By Thomas F. Wall, *M.Sc., M.Eng., Assoc.M.Inst.C.E.*

The single phase repulsion motor partakes partly of the nature of a transformer and partly of the nature of a synchronous machine, and this dual effect gives rise to certain difficulties of treatment which are further complicated by the fact that the flux distribution in the air gap is not sinusoidal.

In the first part of the paper expressions were deduced for the following quantities (the flux distribution in the air gap being taken as triangular or trapezoidal as the case may be) :—

1. The E.M.F. induced in the stator winding due to an alternating current in that winding.
2. The E.M.F. induced in the rotor winding due to an alternating current in the stator winding.
3. The E.M.F. induced in the rotor winding when rotating in the field due to an alternating current in the stator winding.
4. The E.M.F. induced in the stator winding due to an alternating current in the rotor winding.
5. The E.M.F. induced in the rotor winding due to an alternating current in that winding.

Curves were given which have been deduced from the expressions for Nos. 2, 3, and 4, and which enable the values of these E.M.F.s to be rapidly determined for any value of the displacement of the rotor brushes from the stator axis.

In the second part of the paper the above results were employed in developing the theory of the repulsion motor. The theory cannot be explained in a few words, but it results in the establishment of a series of simultaneous equations, the solutions of which give expressions for the speed, stator current, power factor, and power of the motor. It was shown that, if the vector of the applied pressure be drawn in the direction of the ordinate axis, the extremity of the current vector moves over the circumference of a circle which passes through the origin, and that diameter which passes through the origin is inclined to the abscissa axis at a certain angle, the magnitude of which depends upon the resistance and the leakage reactance of the rotor winding. The torque and power of the motor are respectively represented by the distance of the extremity of the current vector from certain lines. The speed is given by the intercept of the current vector on a line drawn at 90° to that diameter of the circle which passes through the origin.

In the third part of the paper the results of some tests on a 6-b.h.p. motor were given, and the agreement of the values of the stator current, the power factor, and the speed as deduced from the theory, and the values determined from the test was shown in the form of curves. The curves have been plotted with the speeds as abscissæ.

Finally a method of calculating the open circuit characteristic of a single-phase motor was given. The applied pressure was assumed to be sinusoidal, and the effect of saturation on the shape of the current wave was taken into account.

4. *Some Preliminary Notes on a Study as to Human Susceptibility to Vibration. By* W. POLLARD DIGBY *and* Captain SANKEY.

The authors pointed out that the variation of individual human sensitiveness has been investigated in regard to senses of taste, sight, sound, and weight; and remarked that the phenomenon of the fact that different persons are affected in different manners by the same conditions of vibration calls for investigation. The phrase 'human susceptibility to vibration' was coined to cover the range of sensitiveness of various people to vibrations of short duration of different amplitude and frequency, together with their opinions as to when these vibrations approached or exceeded the point of being a nuisance.

The authors have employed both verbal standards of degree of vibration and precise unit of measurement. The former ranges from 1 to 8 degrees, imperceptible vibrations being classed as 1, and perceptible vibrations constituting an excessive nuisance as 8. The precise unit of measurement is that of a vibration having a maximum linear amplitude of $\frac{1}{10}$th millimeter at a frequency of 10 cycle per second. From their investigations, so far confined to only a limited number of cases, the authors deduce that :—

(1) The range of vibration classed as imperceptible is a wide one. Generally vibrations having an intensity of 0·10 to 0·20 unit are imperceptible, but are in a lesser number of cases classed as faintly or very faintly perceptible.

(2) In regard to very faintly perceptible vibrations, three persons classed this as under 0·10 unit, six as between 0·10 and 0·20, six as between 0·40 and 0·50, while seven persons could only distinguish vibrations in excess of 0·50 unit.

(3) All individuals show a fatigue effect and lose their sense of discrimination after thirty or forty minutes. Generally the sensitiveness is diminished.

(4) Individuals are divisible into two broad classes. Those capable of discrimination of vibrations of small intensity do not give consistent opinions as to vibrations of large intensity. The opposite effect is observed in those capable of classifying vibrations of larger intensity.

(5) So far the general consensus of opinion points to conditions of perceptible vibration just attaining a nuisance being reached for a mean intensity of one unit. Persons of delicate intensity rate this in the neighbourhood of 0·70 unit, and persons of coarse perceptiveness at about two units.

The authors suggested that it will be of interest to ascertain the effect of variations of conditions of physical health, age, sex, and occupation in this respect.

They concluded by asking for the co-operation of members of the British Association by their acting as subjects for experiment, and urge that from many points of view, not least the legal one, there should be some definition of what exact intensity of vibration constitutes a nuisance. Assistance in the further research contemplated by the authors will only involve spending about forty-five minutes in Westminster, during which time the visitor's hand is placed on a table and the opinions are expressed of the vibration of the table, whether imperceptible, just perceptible, or a nuisance.

5. *Interim Report on Gaseous Explosions.*—See Reports, p. 130.

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6. *The Electrical Conductivity of Light Aluminium Alloys. By* Professor ERNEST WILSON.

The last report on the exposure tests of a certain series of light aluminium alloys was made in 1908.[1] The present paper includes tests made in July 1911.

[1] See *Brit. Assoc. Reports*, 1908.

The copper series have shown that alloying commercial aluminium alone with copper to the extent of 2·6 per cent. is not to be recommended. The copper manganese specimens have not seriously deteriorated in ten years. An alloy known as a 'duralumin' has been tested, and a report is made thereon. Its specific resistance is $5{\cdot}35\times10^{-6}$ ohms at 15° C. as against $2{\cdot}76\times10^{-6}$ for pure commercial aluminium.

MONDAY, SEPTEMBER 4.

Joint Discussion with Section A on Aeronautics.

The Principles of Flight. By ALGERNON E. BERRIMAN.

One of the greatest services that can be rendered to the science of aeronautics at the present time is to attract towards it the serious interest of minds that have matured in other departments of the world's work. With this object in view an attempt will be made to give a *résumé* of the more interesting problems as they are understood by the majority of students, in the hope that those taking part in the discussion may thereby be enabled to direct their remarks along such lines as shall add most to the sum total of our little knowledge in the short space of time available.

The present predominance of the military aspect in the perspective view of the immediate future of aeronautics serves also to draw a dividing line between different forms of aircraft, such as to group all systems essentially possessed of the ability to ascend vertically and hover stationary in the air on one side, and all those that can neither stand still in the air nor get up from anywhere, on the other.

Balloons and Kites.—Thus, the captive balloon and the man-lifting kite both perform useful work, although neither navigates the air at large. The free moving aeroplane, on the other hand, is frequently criticised because it does not at present possess the potential qualities of the as yet unsuccessful helicopter.

The Helicopter.—It seems necessary to pay some attention to the problem of the helicopter, therefore, in order to see how far an elementary investigation of its principles supports the likelihood of realising the possibilities frequently assumed in its favour. It has been suggested that some insects fly on the helicopter principle.

It may be demonstrated that the very small helicopter is a remarkably successful toy, although the large helicopter is as yet an unsuccessful machine. A mathematical ratio (see the 'two-thirds power law' in summary of formulæ) indicates that the application of increased power to a given screw is an inefficient method of increasing the lift. It is suggested that the ratio of essential deadweight to effective lifting area may also increase so disproportionately in large machines as to prevent the practical success of the helicopter class. Inasmuch as the largest screw for a given load is the most efficient, it is argued that the aeroplane is the helicopter of maximum efficiency; inasmuch as it represents a blade element flying on the straight line periphery of a circle of infinite diameter.

Dirigibles.—Under the assumed division, dirigibles and aeroplanes have to be compared as alternative machines for fulfilling the same purpose. Both navigate the air, but the dirigible, in addition, can ascend vertically and hover stationary above any given spot. Windy weather adversely affects both types of machines. In the aeroplane the gust is inimical to stability; in the dirigible a high wind exerts an enormous drifting force. Comparatively large sizes are necessary in dirigibles if they are to have a wide range of action. The more important disadvantages of dirigibles result from the permeability of the fabric to hydrogen, the costliness and inconvenience of using this gas, and the disturbing influences of sunshine and shadow on buoyancy.

Aeroplanes.—The aeroplane is the more interesting machine of the two in the eyes of the majority of students, owing to the popularity of flight as a sport. A broad treatment of the problems relating to this section divides them under

two heads: one dealing with the lift and resistance of the cambered plane, the other dealing with stability, which has always been the most important factor making for progress in aviation.

Calculating Lift.—In the mathematical section, an hypothesis that aeroplanes are supported in flight by the inertia of the air, leads to the necessity of finding plausible expressions for mass and acceleration.

Two dimensions of the mass of air deflected are plausibly functions of the span and chord of the plane; the third, which defines the depth of the stratum and is known as the 'sweep' is taken as an empirical function of the chord, but this connection needs discussion. Acceleration is obviously a function of the angle of the plane, but difference of opinion exists as to how that angle should be measured. A suggestion is put forward in favour of the 'angle of deflection' measured at the point of intersection of tangents drawn to the leading and trailing edges of the plane, which needs discussion. From the assumed premisses a rough and ready formula for lift has been evolved (see summary of formulæ).

Skin Friction.—In order to extend the premisses to cover a plausible expression for the resistance to flight and the power expended thereon, it is necessary to adopt a value for skin friction. Zahm's experiments have been accepted as data (see summary of formulæ), but the whole subject needs discussion. Skin friction is of such fundamental importance in aerodynamics that it is imperative to put it upon an accepted basis analogous to the position occupied by normal pressure.

Coefficient of Flight.—The coefficient of flight, representing the resistance per unit load, may be shown to be independent of speed, but to depend on the angle of the plane and to have a minimum value depending on the coefficient of skin friction. On the present hypothesis, the minimum coefficient of flight obtains with planes of a very small effective angle (about 5°), such as would necessitate flying at much higher speeds than have hitherto been realised. The existence of an angle of least resistance is very important in connection with the problem of variable speed machines.

Body Resistance.—Body resistance in a practical aeroplane is a supplementary resistance to that of the planes, and should always be considered as such. It stands in the way of realising the higher speeds that would lead to the use of more efficient planes, but by enclosing all the principal masses in casings of streamline form a plausible means is afforded of considerably reducing this quantity. A comparison of the coefficients of normal pressure and skin friction indicates a very large possible saving in this direction. In bodies of streamline form the advantages of a hemispherical head are worthy of consideration.

Stability.—Stability in a flying-machine is either natural as a result of form, automatic as the result of self-acting mechanisms, or controlled by human intelligence. No particular progress has been made along the lines of automatic stability, although the use of gyroscopes and wind-vanes to operate relay mechanisms has frequently been suggested. Natural stability has, however, been realised to some extent and, coupled with modern expert control, the combined result has reached an extraordinarily high degree of perfection considering the short period of evolution.

Natural stability in its elementary form may be readily demonstrated by means of paper models. In practical aeroplanes, natural stability in the longitudinal vertical plane is mainly based on the principle of the dihedral angle. Natural stability in the lateral vertical plane is also commonly based on the same principle, but alternative systems, one of which is the arched wing, have been tried. The arched wing and the dihedral being apparently diametrically opposite in principle, attention is drawn to two orders of stability, 'stiff' and 'rolling.' The relative possibilities of successful development along each line is well worthy of discussion.

The ascentric centre of gravity, in which the principal masses are placed well below the centre of pressure, is frequently suggested as a stabilising principle, but the permanent existence of a couple between the centre of gravity and the centre of pressure indicates liability to pronounced oscillation, and the system does not find general favour. In connection with the under-carriages of aeroplanes, the advantage of landing direct on skids is urged, and in connection with the power-plant, the possible disturbing influence of the gyroscopic force of heavy revolving masses is worthy of notice.

Conclusions.—Apart from the question of stability, progress in flying machine design is mainly a problem of increasing the efficiency of the machine, just as it is in every other branch of mechanical engineering. It follows, therefore, that the need for further information on such subjects as the effective angle of a plane, sweep, skin friction, and other similar problems that come within the province of research work in physical science, is all important. If the aeroplane of the future is to carry heavy loads and to fly far and fast without interrupting its journey, it must be more efficient than the aeroplane of to-day. The air, like the ocean, permits of full speed ahead all the time, and a speed of 60 miles per hour through the air would halve the present fastest crossing of the Atlantic. Before an uninterrupted journey across the 1,700 miles that separate the nearest adjacent points of land could be accomplished by a machine carrying only two men it would have to be shown that an aeroplane could be built capable of carrying at least 1,500 lb. of useful load at 60 miles per hour, with a gliding angle more nearly in the order of 1 in 7 than the angle of 1 in 4 or 5 which at present represents the efficiency of a good modern flyer.

Except so far as a pilot might be able to economise power, as soaring birds do, by taking advantage of favourable air-currents, skilful control has nothing to do with the theoretical possibilities of the aeroplane in undertakings of this order, which may be investigated by the aid of simple arithmetic. In matters affecting the use of machines in bad weather, for dangerous purposes, and under difficulties generally, nothing in the world gives any clue to the future except the present state of the art, for which the intrepid practice of pilots and the care of those who build machines is wholly responsible and deserving of the utmost credit.

Summary of Formulæ.

The two-thirds power law.—If thrust $\propto V^2$ and power $\propto V^3$, then thrust $\propto$ H.P.$^{\frac{2}{3}}$.

Mathematics of the cambered plane.—

$$\text{Lift} = \frac{V^2 \tan \beta}{200}$$

where V = flight speed m.p.h.
β = angle of deflection.

Skin friction.—Zahm's formula—

$$R = 0{\cdot}0000316\, l^{\cdot 93} V^{1{\cdot}85}$$

Where R = resistance of double surface lb./ft. of span,
l = chord,
V = velocity m.p.h.

Approximation (1 to 90 m.p.h. and high aspect ratio)

$$R = 0{\cdot}000018 V^2.$$

Coefficient of flight.—

Pounds thrust per lb. loading $= \left[\frac{\tan^2 \beta + 0{\cdot}0072}{2 \tan \beta} \right]$.

Minimum value obtains when $\beta = 5°$ approx., and gives least coefficient of flight $= 0{\cdot}085$.

The following Papers were then read :—

1. *Recent Developments in Radio-Telegraphy.*

By Professor G. W. O. Howe.

The principal cause of the difficulties experienced to-day in maintaining satisfactory communication by means of radio-telegraphy is to be found in the phenomenal growth of this means of transmitting intelligence. The difficulties are mainly due to interference between different stations working simultaneously. Formerly the only disturbance was that due to atmospheric influences, but these are now becoming of less comparative importance, due to the great multiplication of radio-telegraphic equipments and the increasing power used in their sending apparatus. These difficulties promise to increase steadily in the future, and it is therefore a matter of some importance that we should consider the recent developments in the apparatus employed and in the principles involved.

Nearly all the developments, both in the sending and in the receiving

apparatus, have had as their objective the decrease in the interference caused to, or suffered from, other stations. This is, at the present moment, of far greater importance than efficiency.

Since the earliest experiments in radio-telegraphy, it has been realised that it is advantageous to decrease the decrement of the train of waves sent out as the result of each spark. A great improvement in this respect resulted from the use of the coupled aerial, and, with the exception of the spark-gap, no change has been made in the sending apparatus since its introduction. The gap is either stationary and subjected to an air-blast, or the electrodes are revolved at a high speed with or without an air-blast. The most recent development has been the use of very short gaps between copper or silver discs. These quenched-spark gaps allow of much tighter coupling without the production of beats, but undoubtedly represent a great sacrifice of reliability as compared with longer gaps. With the ordinary spark-gap the coupling cannot exceed seven or eight per cent. without the production of beats and the consequently increased interference.

A great improvement has taken place in the nature of the note sent out by most large stations. In the earlier arrangements the sparks followed each other so irregularly, or the spark frequency was so low, that the signal heard in the telephone was nothing more than a crackling noise, very similar to, and easily confounded with, the noises due to atmospheric disturbances. It is not essential to tune out all other signals and extraneous noises, if the signals which have to be received have a distinctive musical note. This has led to the frequency being increased from ten or twenty to five hundred or a thousand sparks per second. The difficulty of getting, with any regularity, a thousand sparks per second with an ordinary gap and a power of several kilowatts will be apparent. If the use of a certain note became general, much of its advantage would be gone, but it would still be a great improvement in combating atmospherics.

Although the receiving arrangements have been made very convenient for rapid tuning, no radical change has been made in the detectors employed. One has still to choose between reliability and sensitiveness. If extreme sensitiveness is not desired, the magnetic detector is ideal in its simplicity. For the reception of weak signals we have the Fleming valve, the electrolytic and various crystal detectors, if necessary, in conjunction with the Brown telephone relay. Attempts have been made to obtain selective working by tuning the reed of the relay, but the general utility of the station so equipped would be greatly reduced, to say nothing of the adjustment and manipulation required.

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2. *Portable Equipment for Wireless Telegraphy.*
By Captain H. Riall Sankey.

TUESDAY, SEPTEMBER 5.

The following Papers were read:—

1. *Economical and Reliable Power Generation by Overtype Superheated-Steam Engines.* *By* W. J. Marshall.

The steam engine is the oldest of all prime movers developing power from the combustion of fuel, and it is undoubtedly the most flexible and reliable. Of late years the internal-combustion engine, on account of its high thermal efficiency and consequently low fuel cost, has attracted the attention of power users very considerably. The effect of this has been to cause steam-engine makers to devote their attention to producing an engine or complete steam plant which will have a fuel economy on a par with that of the internal-combustion engine. This object has been achieved by very careful designing and arrangement of the component parts of a steam-engine plant with a view to reducing the fundamental losses occurring in such a plant to a minimum. The result is the modern over-

type superheated-steam engine, and the first firm to put this type of engine on the market was Messrs. R. Wolf, of Magdeburg, Germany. Wolf engines are running very successfully all over the world. The first English firm to manufacture engines of this type was Messrs. Richard Garrett and Sons, Limited, of Leiston, and while retaining the same principles, they have produced an engine in accordance with the best English practice. The overtype superheated-steam engine consists of a special tubular boiler with the engine mounted on the top of it, the boiler forming the foundation or bed-plate for the engine. A superheater is placed in the smokebox and forms an integral part of the plant, as also do the air pump, condenser, &c., when such are fitted. The result of this arrangement is that steam-pipe losses are reduced to a minimum and the full value of the superheated steam can be employed. The cylinders can also be jacketed with high-pressure steam from the boiler without any loss due to drains or steam traps, as the cylinder casing forms a portion of the steam space of the boiler. The boiler and the superheater are carefully designed as regards their heating surfaces to give the highest efficiency. Particulars of exhaustive trials work were given and comparisons drawn between these and those obtained with a consumption of 1·21 lb. of steam coal per hour. Detailed description of the 'Garrett' engine giving full particulars of its construction was also given, with drawings and photographs showing actual installations of some of these engines in various types of factories. Particulars of actual results obtained in regular work were given and comparisons drawn between these and those obtained with other types of prime mover. The relative importance of the different items which go to make up the cost of power in a factory was discussed, with especial reference to that of reliability.

2. *Suction-Gas Engines and Producers.* *By* W. A. Tookey.

Notwithstanding that during the last ten years or so a very large number of suction-gas plants have been installed in all quarters of the globe with satisfaction to purchasers, as is evidenced by the increasing demand for these simple and economical apparatus, it is a fact that figures recording the actual performances with regard to fuel consumption, cost of maintenance, cost of repair, &c., are difficult to obtain. Yet in order properly to appreciate the claims advanced by the makers of gas engines and gas producers it is very necessary that such records should be available, so that comparisons may be made with competing types of motive-power generators, and more particularly those which, according to test figures, would appear to compete very keenly, if not, indeed, to surpass, gas power-plants in reliable and economical working.

The author has collected from his own tests and those available from various sources, representative performances of suction-gas plants of various sizes when under test, not only when the power can be determined by means of some form of brake dynamometer, but when generating electric current—so taking into account the efficiency of the combined gas-electric set—and also when raising water under different 'heads,' indicating the comparison between fuel consumed and foot-pounds of work performed in such circumstances.

However, inasmuch as 'test' figures are usually obtained under what must be admitted to be abnormal conditions—no account being taken of standby losses, wastage of coal in charging, in removal of ashes, &c., the engine and producer being worked at a constant and regular output for but a limited number of hours—further figures were presented which enable the average performances of suction-gas plants of moderate power to be noted. These figures have been compiled from the statements of factory owners in Great Britain and in European countries. They take into account the variations of consumption due to the different grades of fuel used; they reflect the influence of variations of output, of load fluctuation, of length of standby periods, as well as the effect of the variation in the human element in maintaining or otherwise those conditions which make for the best gas-making and lowest consumption of fuel per unit of power delivered.

Mention was made of the recorded performances of suction-gas engines and plants with regard to non-stop runs, as in information of this character it is possible to realise how reliable are these installations and what little attention

is really needed, provided always that the engine is properly correlated to the producer and the latter to the quality of the fuel and rate of combustion. Figures representing the consumption of lubricating oil were also given, as being of special interest in view of the criticisms that have sometimes been made in this respect. The experiences of users with regard to the cost of maintenance and repairs were also referred to.

The question of capital outlay was next considered for engines and producers fixed complete upon foundations, with piping and all accessories. No figures were quoted for buildings or space occupied, as, after all, these items, though of importance, vary so much in value that no useful purpose would be served by any assumption.

Having thus dealt with the more important considerations that come under survey in the application of gas power, some attention was given to the comparative costs of operation of liquid-fuel engines of the Diesel type, which, although more efficient as regards utilisation of heat units available in the fuel for conversion to power, yet require several conditions to be fulfilled before the higher economy becomes apparent in the pocket of the manufacturer. Similarly, some points were suggested with regard to the relative performances of steam engines of the high-pressure, superheated, compound, condensing, semi-stationary type, to direct attention to the fact that, although according to test results it would appear that suction-gas plants are threatened by a competitor which offers equal economy of operation, there are claims of a negative kind which must incline the balance of advantages in the favour of the gas power-plant, at all events for moderate powers.

3. *The Diesel Oil-Engine.* *By* Chas. Day.

The paper opened with arguments against the selection of an engine being made on makers' guarantees of fuel consumption, as such guarantees cannot possibly cover all working conditions, making it quite possible for the engine which gives the best results on tests to give inferior results over a long period in normal service, when items such as wages, repairs, and maintenance are included. It was urged that the judgment must be based on records of actual working results which include all items of expenditure, and it was pointed out that, owing to the power costs of electricity supply-stations being kept on a uniform basis, and

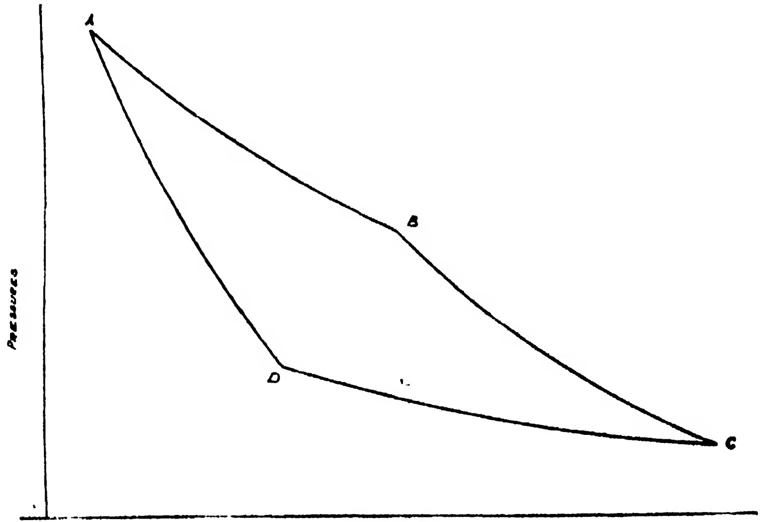

Diagram of Carnot Cycle.

to the great majority of them being published or obtainable, these form the best available data on which to judge the working results obtained with different types of plant.

The author agreed that the conditions of working in some factories differ considerably from those of an electricity supply-station, but claimed that loss of efficiency is largely brought about by causes which are common to all places, and that consequently deductions from electricity-station figures are applicable to the great majority of power cases.

Stations having a plant capacity exceeding 1,000 h p., were excluded from the main comparisons for reasons stated in the paper.

The following table gives a comparison of results of the different types of plant in stations where the plant capacity does not exceed 1,000 h.p.

TABLE I.

Average Cost per B.T.U. Sold.

Type of Engine	Fuel	Lubricating Oil Waste, Stores, and Water	Wages	Repairs & Maintenance	Total Works Cost	Load Factor
Steam . . .	0·45	0·06	0·25	0·26	1·02	14·7
Gas	0·43	0·09	0·28	0·24	1·04	15·3
Diesel . . .	0·23	0·04	0·19	0·07	0·53	14·3

The great saving shown by these figures has been repeatedly confirmed by the experience of the writer, even in cases where the guarantee figures with the Diesel plant have not equalled the figures guaranteed and obtained on test with the previous plants.

A table was given showing the average results obtained from steam stations of various sizes, these averages, like those given in Table I., being deduced from the tables published in the 'Electrical Times' combined with information obtained direct from station engineers.

TABLE II.

Average Works Costs per B.T.U. Sold, on Steam Stations of Different Sizes.

Capacity of Station not exceeding	Fuel	Lubricating Oil, Waste, Water, and Stores	Wages	Repairs and Maintenance	Total	Load Factor
k.w.						
250	0·63	0·09	0·35	0·36	1·43	13·2
500	0·56	0·06	0·27	0·29	1·18	13·3
750	0·43	0·05	0·23	0·24	0·95	15·4
1,000	0·40	0·05	0·23	0·21	0·89	16·8
1,500	0·42	0·04	0·17	0·18	0·81	16·9
2,000	0·37	0·04	0·16	0·21	0·78	17·7
3,000	0·33	0·04	0·15	0·17	0·69	17·4
4,000	0·40	0·03	0·14	0·20	0·77	18·8
5,000	0·34	0·03	0·11	0·16	0·64	18·7
7,000	0·36	0·04	0·13	0·20	0·73	17·9
10,000	0·26	0·03	0·09	0·13	0·51	22·6
20,000	0·30	0·03	0·11	0·16	0·60	19·6
50,000	0·23	0·02	0·10	0·11	0·46	20·56

Constructional features were then dealt with and reasons given in favour of the multi-crank vertical engine, particularly for dynamo driving. For high-speed engines forced lubrication and very complete enclosing were strongly advised.

The development of the Diesel cycle from the Carnot cycle was then briefly

traced, and the following fuel consumptions given as every-day consumptions for Diesel engines of moderate size:—

At full load	0·44 lb. per b.h.p. per hour.
At three-quarter ,, ...	0·45 ,, ,, ,,
At half ,, ...	0·47 ,, ,, ,,
At quarter ,, ...	0·62 ,, ,, ,,

The further advantages resulting with Diesel engines are then briefly stated as: No sparking apparatus, lamp or burner; no carburetter or vaporiser; no back-firing or pre-ignition; no warming up required before starting; very smooth running owing to no explosion or sudden rise of pressure; cheap crude oils used; very little water used; and no ashes or offensive effluents.

In regard to the question of continuous running, a case was quoted where during four years the average running time works out at 23¾ hours out of each 24, or about 1½ hour stoppage per week.

4. *Crude-Oil Marine Engines.*
By James H. Rosenthal, *M.I.N.A.*, *M.I.M.E.*

This paper was not intended to touch at all upon the engines used in launches and yachts which work with alcohol, petrol, or paraffin, and in which such fluids are vaporised and exploded by an electric spark, but was intended to be confined entirely to engines which may be suitable for larger craft, to work entirely with crude oil of a high flash-point, *i.e.*, not explosible. As the author believes that such engines are only possible generally in the larger powers if they are reversible, the paper was confined to two types representative of this description, viz.: (1) Those in which the engines are single-acting and the oil is ignited by means of a heated chamber or hot pot; and (2) those in which the Diesel cycle of combustion is used, and the burning or combustion of the fuel is effected by air compressed in the cylinder to a temperature at which the spray of crude oil will ignite and burn. The question of the supply of crude oil was also touched upon.

The class of engine under (1) which, as far as the writer is aware, is the most largely used for the propulsion of small vessels is that introduced by Messrs. J. & C. G. Bolinder, of Stockholm, under Rundloff's patents, and is made in sizes of from 8 h.p. to 350 h.p.

The class of engine under (2) is made by the Maschinenfabrik Augsburg, Nuernberg, for which in Great Britain Messrs. Harland and Wolff, Ltd., Belfast; the Fairfield Shipbuilding and Engineering Co., Ltd., of Govan, Glasgow; Yarrow and Co., Ltd., Glasgow; John Samuel White and Co., Ltd., of East Cowes, Isle of Wight; Sir W. G. Armstrong, Whitworth and Co., Ltd., of Newcastle-on-Tyne; Messrs. Cammell, Laird and Co., Ltd., of Birkenhead, and Messrs. Babcock and Wilcox, Ltd., of London and Renfrew, are licensees. This engine is made single-acting and double-acting and on the two-cycle principle. The Bolinder engine is also of the two-cycle type and is single-acting. Two-cycle means that it receives a charge every time the piston reaches the top of its stroke. The same applies to the single-acting Nuernberg two-cycle engine. In the double-acting two-cycle Nuernberg engine a charge of oil is injected each time the piston reaches both the top and the bottom of its stroke. Both types of engines were described, and the methods adopted for reversing, and the written matter was explained by illustrations and lantern pictures.

WEDNESDAY, SEPTEMBER 6.

The following Papers were read:—

1. *The Manufacture of Nitrogen Compounds by Electric Power.*
By E. Kilburn Scott, *Assoc.M.Inst.C.E.*

2. *Smoke Abatement: the Possibility of fixing a new Standard of Smoke Emission from Factory Chimneys.* *By* Dr. J. S. Owens.

From the point of view of smoke emission the present position of the manufacturer who burns bituminous coal in his furnace is, that while he knows dense smoke to be unnecessary and wasteful, entire absence of smoke is practically impossible to attain under working conditions. The question therefore is, What is the least amount of smoke such a manufacturer might be asked to limit himself to?

The present legal standard of 'black smoke in sufficient quantity to be a nuisance' is admittedly unsatisfactory, as black smoke is a thing rarely if ever seen; also, the blackness *alone* is no measure of the amount of pollution nor even of the amount of soot per ton of coal burnt. The present standard is therefore out of date. Meanwhile the public have to breathe polluted air, to suffer in health and pocket, have their buildings injured and disfigured, and their sunshine cut off.

A sound standard of maximum allowable amount of smoke should be fixed and enforced. Two questions must be answered before such a standard can be fixed: (1) What is the best and most practicable method of measuring smoke? (2) Having decided on (1), what is a fair maximum of smoke emission to fix, as measured by (1)?

To answer the first question we must decide exactly *what* we are to measure. We may set ourselves to find out: (1) The total quantity of soot emitted in a given time; (2) the weight of soot emitted as a percentage of fuel burnt; (3) the density or weight of soot per unit volume of flue gas; (4) the ratio only of density to a standard; (5) the colour; (6) the opacity or blackness.

In deciding the method of measuring we must keep in view: (*a*) Fair comparison between chimney and chimney or with standard; (*b*) ease of application and simplicity; (*c*) reasonable accuracy; (*d*) the smoke must be measured from outside factory; (*e*) the method must be capable of use by a single observer.

The standard suggested is one of *maximum density for maximum time of emission.* By density is meant amount of soot per unit volume of flue gas. A smoke of great density would be permitted for a short time only, whereas one of less density might be permitted for a longer time.

The method of measuring the density suggested is by matching the opacity of the smoke to that of calibrated smoked glasses, each glass representing a certain density of smoke in a column of unit thickness. The final figure for comparison being obtained by dividing the density represented by the glass by the diameter of the chimney. By careful construction and the elimination of certain errors an instrument can thus be made to give a fair basis of comparison with a standard density. The author has devised and experimented with an instrument of this type, with promising results. Certain objections will always remain to such a method of measuring, but the author believes that it is only along such lines that the necessary conditions can be fulfilled.

The Alkalies Act of 1906 fixes a standard maximum of one-fifth of a grain of muriatic acid per cubic foot in smoke or noxious fumes, and it appears that the time has arrived when the soot from furnaces should be dealt with on similar lines, modified to suit the case.

3. *Continuous versus Intermittent Service in Passenger Transportation.* *By* W. Y. Lewis.

Section H.—ANTHROPOLOGY.

President of the Section.—W. H. R. Rivers, M.D., F.R.S.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

The Ethnological Analysis of Culture.

During the last few years great additions have been made to our store of the facts of anthropology—we have learnt much about different peoples scattered over the earth and we understand better how they act and think. At the same time we have, I hope, made a very decided advance in our knowledge of the methods by means of which these facts are to be collected, so that they may rank in clearness and trustworthiness with the facts of other sciences. When, however, we turn to the theoretical side of our subject, it is difficult to see any corresponding advance. The main problems of the history of human society are little if at all nearer their solution, and there are even matters which a few years ago were regarded as settled which are to day as uncertain as ever. The reason for this is not far to seek; it is that we have no general agreement about the fundamental principles upon which the theoretical work of our science is to be conducted.

In surveying the different schools of thought which guide theoretical work on human culture, a very striking fact at once presents itself. In other and more advanced sciences the guiding principles of the workers of different nations are the same. The zoologists or botanists of France, Germany, America, our own and other countries are on common ground. They have in general the same principles and the same methods, and the work of all falls into a common scheme. Unfortunately this is not so in anthropology. At the present time there is so great a degree of divergence between the methods of work of the leading schools of different countries that any common scheme is impossible, and the members of one school wholly distrust the work of others whose conclusions they believe to be founded on a radically unsound basis.

I propose to consider in this Address one of the most striking of these divergences, but, before doing so, I will put as briefly as possible what seem to me to be the chief characters of the leading schools of different countries. To begin with that dominant among ourselves. The theoretical anthropology of this country is inspired primarily by the idea of evolution founded on a psychology common to mankind as a whole, and further, a psychology differing in no way from that of civilised man. The efforts of British anthropologists are devoted to tracing out the evolution of custom and institution. Where similarities are found in different parts of the world it is assumed, almost as an axiom, that they are due to independent origin and development, and this in its turn is

ascribed to the fundamental similarity of the workings of the human mind all over the world, so that, given similar conditions, similar customs and institutions will come into existence and develop on the same lines.

In France we find that, as among ourselves, the chief interest is in evolution, and the difference is in the principles upon which this evolution is to be studied. It is to the psychological basis of the work of British anthropologists that objection is chiefly made. It is held that the psychology of the individual cannot be used as a guide to the collective actions of men in early stages of social evolution, still less the psychology of the individual whose social ideas have been moulded by the long ages of evolution which have made our own society what it is. It is urged that the study of sociology requires the application of principles and methods of investigation peculiar to itself.[1]

About America it is less easy to speak, because it is unusual in that country to deal to any great extent with general theoretical problems. The anthropologists of America are so fully engaged in the attempt to record what is left of the ancient cultures of their own country that they devote little attention to those general questions to which we, more unfortunately situated with no ancient culture at our doors, devote so much attention. There seems, however, to be a distinct movement in progress in America which puts the evolutionary point of view on one side and is inclined to study social problems from the purely psychological point of view, the psychological standpoint, however, approaching that of the British school more nearly than that of the French.[2]

It is when we come to Germany that we find the most fundamental difference in standpoint and method. It is true that, in Adolf Bastian, Germany produced one who was thoroughly imbued with the evolutionary standpoint, and the *Elementargedanke* of that worker forms a most convenient expression for the psychological means whereby evolution is supposed to have proceeded. In recent years, however, there has been a very decided movement opposed to Bastian and the whole evolutionary school. In some cases this has formed part of that general revolt not merely against Darwinism which is so prominent in Germany, but it seems even against the whole idea of evolution. In other cases the objection is less fundamental, and has been not so much to the idea of evolution itself as to the lines upon which it has been customary to endeavour to study this evolution.

This movement, which by those who follow it is called the geographical movement, but which, I think, may be more fitly styled 'ethnological,' was originated by Ratzel, who was first led definitely in this direction by a study of the armour made of rods or plates or laths which is found in North America, northern Asia, including Japan, and in a less developed form in some of the islands of the Pacific Ocean.[3] Ratzel believed that the resemblances he found could only be explained by direct transmission from one people to another and was led by further study to become an untiring opponent of the *Elementargedanke* of Bastian and of the idea of independent evolution based on a community of thought.[4] He has even suggested that the idea of independent origin is the anthropological equivalent of the spontaneous generation of the biologist and that anthropology is now going through a phase of development from which biology has long emerged.

The movement initiated by Ratzel has made great progress, especially through

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[1] I refer here especially to the work of the 'sociological' school of Durkheim and his followers. For an account of their principles and methods see *L'Année sociologique*, which began to appear in 1898; Durkheim, *Les Règles de la Méthode Sociologique*, Paris; and Lévy-Bruhl, *Les fonctions mentales dans les sociétés inférieures*, Paris, 1910.

[2] See especially A. L. Kroeber, 'Classificatory Systems of Relationship,' *Journ. Roy. Anthr. Inst.*, 1909, xxxix., 77; and Goldenweiser, 'Totemism: An Analytical Study,' *Journ. Amer. Folk-Lore*, 1910, xxiii.

[3] *Sitzber. d. Akad. d. Wiss. München*, Hist. Cl., 1886, p. 181.

[4] See especially *Anthropogeographie*, 1891, Th. ii., 705, and 'Die geographische Methode in der Ethnographie,' *Geograph. Zeitsch.*, 1897, iii., 268.

the work of Graebner[5] and of P. W. Schmidt.[6] It has resulted in an important series of works in which the whole field of anthropological research is approached in a manner wholly different from that customary in this country.[7] I must content myself with one example to illustrate the difference of standpoint which separates the two schools. Few subjects have attracted more interest in this and other countries than the study of primitive decoration. In the decorative art of all lands there are found transitions from designs representing the human form or those of animals and plants to patterns of a purely geometrical nature. In this country it has been held, I think I may say universally, that in these transitions we have evidence for an evolutionary process which in all parts of the world has led mankind to what may be called the degradation and conventionalisation of human, animal, or plant designs so that in course of time they become mere geometrical forms.

To the modern German school, on the other hand, these transitions are examples of the blending of two cultures, one possessing the practice of decorating their objects with human, animal, or plant designs, while the art of the other is based on the use of geometrical forms. The transitions which have been taken to be evidence of independent processes of evolution based on psychological tendencies common to mankind are by the modern German school ascribed to the mixture of cultures and of peoples. Further, similar patterns, even one so simple as the spiral, when found in widely separated regions of the earth, are held to have been due to the influence of one and the same culture.

I have chosen this example because it illustrates the immense divergence in thought and method between the two schools, but the difference runs through the whole range of the subject. In every case where British anthropologists see evolution, either in the forms of material objects or in social and religious institutions, the modern German school sees only the evidence of mixture of cultures, either with or without an accompanying mixture of the races to which these cultures belonged.

It will, I think, be evident that this difference of attitude of British and German workers is one of fundamental and vital importance. When we find the chief workers of two nations thus approaching their subject from two radically different, and it would seem, incompatible standpoints, it is evident that there must be something very wrong, and it has seemed to me that I cannot better use the opportunity given to me by the present occasion than in devoting my address to this subject.

The situation is one which has an especial interest for me in that I have been led quite independently to much the same general position as that of the German school by the results of my own work in Oceania with the Percy Sladen Trust Expedition. With no knowledge of the work of this school I was led by my facts to see how much, in the past, I had myself ignored considerations arising from racial mixture and the blending of cultures, and it will perhaps interest you if I sketch briefly the history of my own conversion.

Much of my time in Oceania was devoted to survey work, in which I collected especially the systems of relationship of every place I visited, together with such other facts concerning social organisation as I was able to gather. I

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[5] See especially Graebner, *Methode der Ethnologie*, Heidelberg, 1911, and 'Die melanesische Bogenkultur und ihre Verwandten,' *Anthropos*, 1909, iv., 726. The annual *Ethnologica*, edited by W. Foy, is devoted to the illustration of this school of thought.

[6] See especially 'L'origine de l'Idée de Dieu,' *Anthropos*, iii.–v., 1908–10, and 'Grundlinien einer Vergleichung der Religion u. Mythologie der austronesischen Völker, *Denksch. d. Akad. d. Wiss. Wien*, Phil.-hist. Kl., 1910, liii. Schmidt differs from Graebner in limiting the application of the ethnological method to regions with general affinities of culture. Otherwise he remains an adherent of the doctrine of independent origin. (See 'Panbabylonismus und ethnologischer Elementargedanke,' *Mitt. d. anthrop. Gesellsch. in Wien*, 1908, xxxviii., 73.)

[7] It must not be understood from this account that all German anthropologists are adherents of the ethnological school. There are still those who follow the doctrines of Bastian, which have undergone an interesting modification through the adoption of the biological principle of Convergence.

began my theoretical study by a comparison of the various forms of those systems of relationship, disregarding at first the linguistic nature of the terms. From the study of these systems I was able to demonstrate the existence either in the present or the past of a number of extraordinary and anomalous forms of marriage, such as marriage with the daughter's daughter and with the wife of the father's father,[*] all of which become explicable if there once existed widely throughout Melanesia a state which is known as the dual organisation of society with matrilineal descent accompanied by a condition of dominance of the old men which enabled them to monopolise all the young women of the community. Taking this as my starting-point, I was then able to trace out a consistent and definite scheme of the history of marriage in Melanesia from a condition in which persons normally and naturally married certain relatives to one in which wives are purchased with whom no relationship whatever can be traced, and I was able to fit many other features of the social structure of Melanesia into this scheme. So far my work was of a purely evolutionary character, and only served to strengthen me in my previous standpoint.

I then turned my attention to the linguistic side of the systems of relationship, and a study of the terms themselves showed that these fell into two main classes: one class generally diffused throughout Oceania, while the terms of the other class differed very considerably in different cultural regions. Further, it became clear that the terms of the first class denoted relationships which my comparative study of the forms of the systems had shown to have suffered change, while the terms which varied greatly in different parts of Oceania denoted relationships, such as those of the mother and mother's brother, which there was no reason to believe had suffered any great change in status. From these facts I inferred that at the time of the most primitive stage of Melanesian society of which I had evidence, there had been great linguistic diversity which had been transformed into the relative uniformity now found in Melanesia by the incoming of a people from without, through whose influence the change I had traced had taken place, and from whose language the generally diffused terms of relationship had been borrowed. It was through the combined study of social forms and of language that I was led to see that the change I had traced was not a spontaneous evolution, but one which had taken place under the influence of the blending of peoples. The combined morphological and linguistic study of systems of relationship had led me to recognise that a definite course of social development had taken place in an aboriginal society under the influence of an immigrant people.

I turned next to a Melanesian institution, that of secret societies, concerning which I had been able to gather much new material, and it soon became probable that these societies belonged properly neither to the aboriginal culture nor to that of the immigrants, but had arisen as the result of the interaction of the two; that, in fact, these secret societies had had their source in the need felt by the immigrants for the secret practice of the rites they had brought with them from their former home. A comparison of the ritual of the secret societies with the institutions of other parts of Oceania then made it appear that the main features of the culture of these immigrants had been patrilineal descent, or at any rate definite recognition of the relation between father and child, a cult of the dead, the institution of taboo, and, lastly, certain relations with animals and plants which were probably allied to totemism, if they were not totemism itself in a fully developed form.

Further study made it clear that those I have called the immigrant people, though possessing these features in common, had reached Melanesia at different times and with several decided differences of culture, but that probably there had been two main streams: one which peopled Polynesia and became widely diffused throughout Melanesia, which was characterised by the use of kava; another which came later and penetrated much less widely, which brought with it the practice of chewing betel-mixture. Traces of a third stream, the earliest of all, are probably to be found here and there throughout Melanesia, while still another element is provided by recent Polynesian influence. It became evident that the present condition of Melanesian society has come into being through the blending of an aboriginal population with various peoples from

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[*] These terms are used in the classificatory sense.

without, and it therefore became necessary to ascertain to which of the cultures possessed by these peoples the present-day customs and institutions of Melanesia belong, always keeping in mind the possibility that some of these institutions may not have belonged to any one of the cultures, but may have arisen as the result of the interaction of two or more of the blending peoples.

I must be content with this brief sketch of my scheme of the history of Melanesian society, for my object to-day is to point out that if Melanesian society possesses the complexity and the heterogeneous character I have indicated and is the resultant of the mixture of three or four main cultures, it cannot be right to take out of the complex any institution or belief and regard it as primitive merely because Melanesian culture on the whole possesses a more or less primitive character. It is probable that some of the immigrants into Melanesia had a relatively advanced culture, possibly even that the institutions and ideas they brought with them had been taken from a culture higher still, and, therefore, when we bring forward any Melanesian institution or belief as an example of primitive thinking or acting, our first duty should be to inquire to which stratum of Melanesian culture it belongs.

To illustrate my meaning I have time for only one example. No concept of Melanesian culture has bulked more largely in recent speculation than that of *mana*, the mysterious virtue to which the magico-religious rites of Melanesia are believed to owe their efficacy. This word now seems on its way to enter the English language as a term for that power or virtue which induces the emotions of awe and wonder, and thus provides a most important element not only in the specific mental states which underlie religion, but also plays much the same part in the early history of magic. In recent speculation the idea of *mana* is coming to be regarded as having been the basis of religious ideas and practices preceding the animism which, following Professor Tylor, we have for long regarded as the earliest form of religion, and *mana* is thus held to be not only the foundation of pre-animistic religion, but also the basis of that primitive element of human culture which can hardly be called either religion or magic, but is the common source from which both have been derived. If I am right in my analysis of Oceanic culture, the Melanesian concept of *mana* is not a suitable basis for these speculations. It is certain that the word *mana* belongs to the culture of the immigrants into Melanesia and not to that of the aborigines. It is, of course, possible that though the word belongs to the immigrant culture, the ideas which it connotes may belong to a more primitive stratum, but this is a pure assumption and one which I believe to be contrary to all probability. At any rate, we can be confident that even if the ideas connoted by the term *mana* belong to or were shared by the primitive stratum of Melanesian society, they must have been largely modified by the influence of the alien but superior culture from which the word itself has been taken. I believe that the Melanesian evidence can legitimately be used in favour of the view that the power or virtue denoted by *mana* is a fundamental element of religion. The analysis of culture, however, indicates that it is not legitimate to use the Melanesian evidence to support the primitiveness of the concept of *mana*. This evidence certainly does not support the view that the concept of *mana* is more primitive than animism, for the immigrants were already in a very advanced stage of animistic religion, a cult of the dead being certainly one of the most definite of their religious institutions.

Further, I believe that the use of the term *mana* in Melanesia in connection with magic, as a term for that attribute of objects used in magic to which they owe their efficacy, is due to an extension of the original meaning of the term, and that it would only be misleading to use the Melanesian facts as evidence in favour of the concept of *mana* as underlying primitive magic. Here, again, I do not wish to deny that a concept such as that denoted by *mana* may be a primitive element of magic; all that I wish to point out is that the Melanesian evidence cannot properly be used to support this view, for the use of the term in connection with magic in Melanesia is not primitive but secondary and relatively late.

The point, then, on which I wish to insist is that if cultures are complex, their analysis is a preliminary step which is necessary if speculations concerning the evolution of human society, its beliefs and practices, are to rest on a firm foundation.

I have so far dealt only with Melanesia. It is obvious that the same principle that analysis of culture must precede speculations concerning the evolution of

institutions is of wider application, but I have time only to deal, and that very briefly, with one other region.

No part of the world has attracted more attention in recent anthropological speculation than Australia, and at the bottom of these speculations, at any rate in this country, there has usually been the idea, openly expressed or implicitly understood, that, in the culture of this region, we have a homogeneous example of primitive human society. From the time that I first became acquainted with Australian sociology, I have wondered at the complacency with which certain features of Australian social organisation have been regarded, and especially the combination of the dual organisation and matrimonial classes with what appear to be totemic clans like those of other parts of the world. This co-existence of two different forms of social organisation side by side has seemed to me the fundamental problem of Australian society, and I confess that till lately, obsessed as I see now I have been by a crude evolutionary point of view, the condition has seemed an absolute mystery.[9] A comparison, however, of Australia and Melanesia has now led me to see that probably we have in Australia, not merely another example of mixture of cultures, but even another resultant of mixture of the same or closely similar components as those which have peopled Melanesia, viz., a mixture of a people possessing the dual organisation and matrilineal descent with one organised in totemic clans, possessing either patrilineal descent, or at any rate clear recognition of the relation between father and child. This is no new view, having been already advanced, though in a different form, by Graebner[10] and P. W. Schmidt.[11] If further research should show Australian society to possess such complexity, it will at once become obvious that here also ethnological analysis must precede any theoretical use of the facts of Australian society in support of evolutionary speculations.

It may be objected that we all recognise the complexity of culture, and indeed in the study of regions such as the Mediterranean, where we possess historical evidence, it is this complexity which forms the chief subject of discussion. Further, where we possess historical evidence, as in the cases of the Hindu and Mahommedan invasions into the Malay Archipelago, all anthropologists are fully alive to the complexities and difficulties introduced thereby into the study of culture; but where we have no such historical evidence, the complexity of culture is almost wholly ignored by those who use those cultures in their attempts to demonstrate the origin and course of development of human institutions.

I have now fulfilled the first purpose of this address. I have tried to indicate that evolutionary speculations can have no firm basis unless there has been a preceding analysis of the cultures and civilisations now spread over the earth's surface. Without such analysis it is impossible to say whether an institution or belief possessed by a people who seem simple and primitive may not really be the product of a relatively advanced culture forming but one element of a complexity which at first sight seems simple and homogeneous.

Before proceeding further I should like to guard against a possible misconception. Some of those who are interested in the ethnological analysis of culture regard it not only as the first but as the only task of the anthropology of to-day. I cannot too strongly express my disagreement with this view. Because I have insisted on the importance of ethnological analysis, I hope you will not for a moment suppose that I underrate the need for the psychological study of customs and institutions. If the necessity for the ethnological analysis of culture be recognised, this psychological study becomes more complicated and difficult than it has seemed to be in the past, but that makes it none the less essential. Side by side with ethnological analysis there must go the attempt to fathom the modes of thought of different peoples, to understand their ways of regarding and classifying the facts of the universe. It is only by the combination of ethnological and psychological analysis that we shall make any real advance.

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[9] I may note here that Mr. Lang, after having considered this problem from the purely evolutionary standpoint (*Anthropological Essays presented to E. B. Tylor*, p. 203), concludes with the words, 'We seem lost in a wilderness of difficulties.'

[10] *Zeitsch. f. Ethnol.*, 1905, xxxvii., 28, and 'Zur australischen Religionsgeschichte,' *Globus*, 1909, xcvi., 341.

[11] See especially *Zeitsch. f. Ethnol*, 1909, xli., 340.

To-day however, time will not allow me to say more about this psychological analysis, and I must continue the subject from which I have for a moment turned aside.

Having shown the importance of ethnological analysis, I now propose to consider the process of analysis itself and the principles on which it should and must be based if it in its turn is to have any firm foundation. In the analysis of any culture a difficulty which soon meets the investigator is that he has to determine what is due to mere contact and what is due to intimate intermixture, such intermixture, for instance, as is produced by the permanent blending of one people with another either through warlike invasion or peaceful settlement. The fundamental weakness of most of the attempts hitherto made to analyse existing cultures is that they have had their starting-point in the study of material objects, and the reason for this is obvious. Owing to the fact that material objects can be collected by anyone and subjected at leisure to prolonged study by experts, our knowledge of the distribution of material objects and of the technique of their manufacture has very far outrun that of the less material elements. What I wish now to point out is that in distinguishing between the effects of mere contact and the intermixture of peoples, material objects are the least trustworthy of all the constituents of culture. Thus, in Melanesia we have the clearest evidence that material objects and processes can spread by mere contact without any true admixture of peoples and without influence on other features of the culture. While the distribution of material objects is of the utmost importance in suggesting at the outset community of culture, and while it is of equal importance in the final process of determining points of contact and in filling in the details of the mixture of cultures, it is the least satisfactory guide to the actual blending of peoples which must form the solid foundation of the ethnological analysis of culture. The case for the value of magico-religious institutions is not much stronger. Here, again, in Melanesia there is little doubt that whole cults can pass from one people to another without any real intermixture of peoples. I do not wish to imply that such religious institutions can pass from people to people with the ease of material objects, but to point out that there is evidence that they can and do so pass with very little, if any, admixture of peoples or of the deeper and more fundamental elements of the culture. Much more important is language, and if you will think over the actual conditions when one people either visit or settle among another, this greater importance will be obvious. Let us imagine a party of Melanesians visiting a Polynesian island, staying there for a few weeks and then returning home (and here I am not taking a fictitious occurrence but one which really happens). We can readily understand that the visitors may take with them their betel mixture and thereby introduce the custom of betel-chewing into a new home; we can readily understand that they may introduce an ornament to be worn in the nose and another to be worn on the chest; that tales that they tell will be remembered, and dances they perform will be imitated. A few Melanesian words may pass into the language of the Polynesian island, especially as names for the objects or processes which the strangers have introduced, but it is incredible that the strangers should thus in a short visit produce any extensive change in the vocabulary and still more that they should modify the structure of the language. Such changes can never be the result of mere contact or transient settlement, but must always indicate a far more deeply seated and fundamental process of blending of peoples and cultures.

Few will perhaps hesitate to accept this position, but I expect my next proposition to meet with more scepticism, and yet I believe it to be widely, though not universally, true.[12] This proposition is that the social structure, the framework of society, is still more fundamentally important and still less easily changed except as the result of the intimate blending of peoples, and for that reason furnishes by far the firmest foundation on which to base the process of analysis of culture. I cannot hope to establish the truth of this proposition in the course of a brief address, and I propose to draw your attention to one line of evidence only.

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[12] There are definite exceptions in Melanesia; places where the social structure has been transformed, though the ancient language persists.

At the present moment we have before our eyes an object-lesson in the spread of our own people over the earth's surface, and we are thus able to study how external influence affects different elements of culture. What we find is that mere contact is able to transmit much in the way of material culture. A passing vessel which does not even anchor may be able to transmit iron, while European weapons may be used by people who have never even seen a white man. Again, missionaries introduce the Christian religion among people who cannot speak a word of English or any language but their own, or only use such European words as have been found necessary to express ideas or objects connected with the new religion. There is evidence how readily language may be affected, and here again the present day suggests a mechanism by which such a change takes place. English is now becoming the language of the Pacific and of other parts of the world, through its use as a *lingua franca*, which enables natives who speak different languages to converse not only with Europeans but with one another, and I believe that this has often been the mechanism in the past; that, for instance, the introduction of what we now call the Melanesian structure of language was due to the fact that the language of the immigrant people who settled in a region of great linguistic diversity came to be used as a *lingua franca*, and thus gradually became the basis of the languages of the whole people.

But now let us turn to social structure. We find in Oceania islands where Europeans have been settled as missionaries or traders perhaps for fifty or a hundred years; we find the people wearing European clothes and European ornaments, using European utensils, and even European weapons when they fight; we find them holding the beliefs and practising the ritual of a European religion; we find them speaking a European language often even among themselves, and yet investigation shows that much of their social structure remains thoroughly native and uninfluenced not only in its general form but often even in its minute details. The external influence has swept away the whole material culture, so that objects of native origin are manufactured only to sell to tourists; it has substituted a wholly new religion and destroyed every material, if not every moral, vestige of the old; it has caused great modification and degeneration of the old language; and yet it may have left the social structure in the main untouched. And the reasons for this are clear. Most of the essential social structure of a people lies so below the surface; it is so literally the foundation of the whole life of the people that it is not seen; it is not obvious, but can only be reached by patient and laborious exploration. I will give a few specific instances. In several islands of the Pacific, some of which have had European settlers on them for more than a century, a most important position in the community is occupied by the father's sister.[13] If any native of these islands were asked who is the most important person in the determination of his life-history, he would answer, 'My father's sister,' and yet the place of this relative in the social structure has remained absolutely unrecorded, and, I believe, absolutely unknown to the European settlers in these islands. Again, Europeans have settled in Fiji for more than a century, and yet it is only during this summer that I have heard from Mr. A. M. Hocart, who is working there at present, that there is the clearest evidence of what is known as the dual organisation of society as a working social institution at the present time. How unobtrusive such a fundamental fact of social structure may be comes home to me in this case very strongly, for it wholly eluded my own observation during a visit three years ago.

Lastly, the most striking example of the permanence of social structure which I have met is in the Hawaian Islands. There the original native culture is reduced to the merest wreckage. So far as material objects are concerned, the people are like ourselves; the old religion has gone, though there probably still persists some of the ancient magic. The people themselves have so dwindled in number, and the political conditions are so altered, that the social structure has also necessarily been greatly modified, and yet I was able to ascertain that one of its elements, an element which I believe to form the deepest layer of the foundation, the very bedrock of social structure, the system of relationship, is

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[13] See *Folk-Lore*, 1910, xxi., 42.

still in use unchanged. I was able to obtain a full account of the system as actually used at the present time, and found it to be exactly the same as that recorded forty years ago by Morgan and Hyde, and I obtained evidence that the system is still deeply interwoven with the intimate mental life of the people.

If then social structure has this fundamental and deeply-seated character, if it is the least easily changed and only changed as the result either of actual blending of peoples or of the most profound political changes, the obvious inference is that it is with social structure that we must begin the attempt to analyse culture and to ascertain how far community of culture is due to the blending of peoples, how far to transmission through mere contact or transient settlement.

The considerations I have brought forward have, however, in my opinion, an importance still more fundamental. If social institutions have this relatively great degree of permanence, if they are so deeply seated and so closely interwoven with the deepest instincts and sentiments of a people that they can only gradually suffer change, will not the study of this change give us our surest criterion of what is early and what is late in any given culture, and thereby furnish a guide for the analysis of culture? Such criteria of early and late are necessary if we are to arrange the cultural elements reached by our analysis in order of time, and it is very doubtful whether mere geographical distribution itself will ever furnish a sufficient basis for this purpose. I may remind you here that before the importance of the complexity of Melanesian culture had forced itself on my mind, I had already succeeded in tracing out a course for the development of the structure of Melanesian society, and after the complexity of the culture had been established, I did not find it necessary to alter anything of essential importance in this scheme. I suggest, therefore, that while the ethnological analysis of cultures must furnish a necessary preliminary to any general evolutionary speculations, there is one element of culture which has so relatively high a degree of permanence that its course of development may furnish a guide to the order in time of the different elements into which it is possible to analyse a given complex.

If the development of social structure is thus to be taken as a guide to assist the process of analysis, it is evident that there will be involved a logical process of considerable complexity in which there will be the danger of arguing in a circle. If, however, the analysis of culture is to be the primary task of the anthropologist, it is evident that the logical methods of the science will attain a complexity far exceeding those hitherto in vogue. I believe that the only logical process which will in general be found possible will be the formulation of hypothetical working schemes into which the facts can be fitted, and that the test of such schemes will be their capacity to fit in with themselves, or as we generally express it, 'explain' new facts as they come to our knowledge. This is the method of other sciences which deal with conditions as complex as those of human society. In many other sciences these new facts are discovered by experiment. In our science they must be found by exploration, not only of the cultures still existent in living form but also of the buried cultures of past ages.

And here is the hopeful aspect of our subject. I believe our present store of facts, at any rate on the less material sides of culture, to form but a very small part of that which is yet to be obtained, and will be obtained unless we very wilfully neglect our opportunities. Waiting to be collected there is a vast body of knowledge by means of which to test the truth of schemes of the history of mankind, not only of his migrations and settlements but of the institutions and objects which have arisen at different stages of this history and developed into various forms throughout the world.

And this brings me to my concluding topic. I have tried to show that any speculations concerning the history of human institutions can only have a sound basis if cultures have first been analysed into their component elements, but I do not wish for one moment to depreciate the importance of attempts to seek for the origin and early history of human institutions. To me the analysis of culture is merely the means to an end which would have little interest if it did not show us the way to the proper understanding of the history of human institutions. The importance of the facts of ethnology in the study of civilised culture is now generally recognised. You can hardly take up a modern work

dealing with any aspect of human thought and activity without finding reference to the customs and institutions of savage or barbarous peoples. It is becoming recognised that a study of these helps us to understand much that is obscure in our own institutions or in those of other great civilisations of the present or the past. Further, there can be no doubt that we are only at the threshold of a new movement in learning which is being opened by this comparative study.

It is a cruel irony that just as the importance of the facts and conclusions of ethnological research is thus becoming recognised, and just as we are beginning to learn sound principles and methods for use both in the field and in the study, the material of our science is vanishing. Not only is the march of our own civilisation into the hitherto undisturbed places of the earth more rapid than it has ever been before, but this advance has made more easy the spread of other destroying agencies. In many parts of such a region as Melanesia, it is even now only from the old men that any trustworthy information can be obtained, and it is no exaggeration to say that with the death of every old man there and in many other places there goes, and goes for ever, knowledge the disappearance of which the scholars of the future will regret as the scholars of the past regretted such an event as the disappearance of the library of Alexandria. There is no other science in the same position. The nervous system of an animal, the metabolism of a plant, the condition of the South Pole, for instance, will be a hundred, or even a thousand, years hence essentially what they are to-day, but long before the shorter of those times has passed, most, if not all, of the lower cultures now found on different parts of the earth will have wholly disappeared or have suffered such change that little will be learnt from them. Fortunately the need for ethnographical research is now forcing itself on the attention of those who have to deal with savage or barbarous peoples. Statesmen have begun to recognise the practical importance of knowledge of the institutions of those they have to govern, and missionary societies are beginning to see, what every wise missionary has long known, that it is necessary to understand the ideas and customs of those whose lives they are trying to reform. Still, we must not be content with these more or less official movements. There is ample scope, indeed urgent need, for individual effort and for non-official enterprise. It is not all who can go into the field and do the needed work themselves, but there is none who cannot in some way help to promote ethnographical research. We have before us one of those critical occasions which must be seized at once if they are to be seized at all: the occasion of a need which to future generations will seem to have been so obvious that its neglect will be held an enduring reproach to the science of our time.

The following Papers were then read :—

1. *The Reverence for the Cow in India.* *By* W. Crooke, *B.A.*

Among many pastoral and agricultural tribes the bull and cow, as well as other domesticated animals, are regarded with respect and affection. This feeling, however, does not suffice to account for the passionate reverence shown to the cow in India. The animal is worshipped at various domestic rites; the use of beef is rigidly prohibited; and even in recent years fanatical mobs have engaged in riots, sometimes involving serious loss of life, as a protest against the custom in vogue among Muhammadans of slaying a cow at one of their festivals.

Dealing with the question from the historical point of view, the literary evidence proves that the bull and cow were recognised as sacred animals, not necessarily totems, from the Indo-Iranian period. Besides the abundant literary evidence, the sanctity of the animal is proved by the wide diffusion of taboos connected with milk and other products of the cow.

The difficulty which some modern writers have felt in discussing the problem of the sanctity of the cow has been increased by the fact that, while she was revered, the cow was, in the Vedic age, habitually sacrificed, and her flesh was consumed by the worshippers. This fact is now explained on the principles which have been investigated by Professors W. Robertson Smith and J. G. Frazer, who have pointed out that the killing of the sacred animal and the eating of its

flesh was a mode of gaining sacramental communion with the divine animal. The view that among the early Hindus beef-eating was generally practised merely from the desire for this special food may be dismissed.

The bearing of the doctrine of metempsychosis and totemism, as explaining the modern veneration felt for the animal, was considered.

From an examination of the facts the conclusion suggested is that, while its claims to veneration were partially ignored by Buddhism, for various reasons the cow came to be recognised as the specially sacred animal of the Brahmans. On the rise of the neo-Brahmanism, after the decay of Buddhism, Brahman patronage of the animal was extended. It was associated with the work of the missionary ascetics, with the cults of Siva and Krishna, and was adopted in various domestic rites conducted under Brahman superintendence.

The passionate reverence for the cow is thus shown to be, in a large measure, due to Brahman influence, and the priestly class has been the main agent in encouraging the modern feeling.

2. *On the Origin of Rest Days.* *By* Professor HUTTON WEBSTER.

The custom of refraining from labour and other activities is by no means unknown to peoples of primitive or archaic culture. Frequently, as associated practices, there may be fasting, either partial or complete, bright and gay clothing may be laid aside, fires and lights extinguished; dancing, singing, even loud talking forbidden. In such circumstances a season of abstinence from labour passes into a season of complete quiescence.

Communal rest-days with these characteristics may be studied among such contemporary peoples as the Dyaks of Borneo and the Nagas of Assam. They were a constant feature of old Polynesian life, particularly among the Hawaiian Islanders, whose *tabu* periods are well known. It would seem that in these regions taboos imposing various sorts of abstinence are declared at critical occasions, such as planting and harvesting, after an earthquake or a pestilence, very frequently after a death, at the changes of the moon, and at other times of crisis. The regulations are to be regarded primarily as protective and conciliatory measures, but they appear also to be sometimes considered as of compelling power over evil spirits.

It is probable that the anthropological data may help to explain, on the one hand, the familiar phenomenon of 'unlucky days,' and, on the other hand, the Sabbatarian regulations found among the Romans, the Babylonians, and the Hebrews.

3. *Some Notes on Hausa Folk-lore.* *By* Major A. J. N. TREMEARNE, *B.A.*

The Hausas occupy most of what is now Northern Nigeria, and a good deal of the French territory to the west, though whether they originally came from the north or north-east, or whether they are indigenous, is still a moot question.

They are very fond of tales and proverbs, and almost every well-known animal and nearly every trade or profession are represented in the folk-lore of the people.

The Spider is the king of cunning, and after each account the narrator excuses himself for his untruths by stating that the story has been told in the name of this insect. The dog is not at all sagacious.

The desire of motherhood is strongly implanted in the Hausas, several stories relating how a woman prayed to have offspring whatever it might be. And even abnormal children were welcome in the stories, though it is doubtful if they were well treated in actual life.

There is some magic in names, the first child being often known by a nickname, and there is great reluctance on the part of the mother to allow the father to see her nursing her first child. Wives must not mention the names of their husbands. Some slave-names correspond to our 'Praise God Barebones.' Parents are usually kind to their children, but there are many tales of stepmothers which give the contrary idea, some of them resembling 'Cinderella.'

There seem to have been sacrifices of young girls to a water-god, one story reminding one of Jephtha's Daughter. The object of the sacrifice was to

prevent a flood, and the victim was said to marry the water-god. The Magazawa still worship various spirits, but the great majority of the Hausa people is now Muhammadan, having been converted by the Filani, who conquered the Hausa States one hundred years ago.

Differences in rank and status are clearly recognised: a poor man 'dies,' but a chief 'is missing.' Although animals can take human form, and *vice versa*, there is a distinction in describing defects of each; thus, a man 'is lame,' but a horse 'has no leg.' A blind man is very cunning. To compliment a woman on her looks may bring misfortune upon her. A figure-target set up in the barracks was objected to by the women, who feared a miscarriage through having seen it.

There is a peculiar institution called *Bori*. It originated as a cure for insanity, but is now practised mainly by the people of loose morals. There are many divisions of it, the persons belonging to them simulating some form of insanity. There is a regular form of initiation.

Most of the tales are told in a sing-song voice, but sometimes words are introduced to represent the sounds of the animals or birds speaking, one of the best-known being a conversation between a hyæna and dogs.

4. *An Archæological Classification of American Types of Prehistoric Artifacts.* *By* WARREN K. MOOREHEAD.

Until recently no attempt had been made to classify the thousands of objects of stone, bone, wood, metal, &c., made and used by primitive man in America. Some three or four years ago a committee, of which the author was a member, was formed for this purpose. The main outlines of the system of classification which this committee have proposed are as follows:—

Class I.—Chipped stone.

I. Without stem. — Chipped stone, knives and projectile points: (*a*) Without secondary chipping; (flakes): (*b*) With secondary chipping: (1) Pointed at one end, (2) Base concave, (3) Base straight, (4) Base convex, (5) Sides convex, &c.

II. With stem.—(*a*) Stem expanding from base: (1) Base concave, (2) Base straight, (3) Base convex; (*b*) Stem with sides parallel (subdivided as II*a*); (*c*) Stem contracting from base (subdivided as II*a*).

Class II.—Scrapers.

Class III.—Perforators.

Class IV.—Hammerstones, Ground Stone.

Problematical Forms.

These include the great range of American 'unknown' objects. No previous attempt at classification was made. The flat surfaces were grouped under the term Laminæ:—

Types: (*a*) Spade-shaped: Ovate, sides concave, sides convex, sides straight; (*b*) Leaf-shaped, spear-shaped; (*c*) Rectangular; (*d*) Shield-shaped; (*e*) Pendants, celt-shaped, rectangular, oval, &c.

Resemblances to known forms in life: (*a*) Animal-shaped stones; (*b*) Bird-shaped stones; (*c*) Boat-shaped stones.

Here follows a long series of other problematical forms which cannot be listed in a brief abstract.

Articles in Clay.

This covers the range of ceramics in the United States. Over this the committee spent much labour. The types are so numerous that a full synopsis cannot be given briefly.

Body, greatly varying; Neck, cylindrical, expanding, contracting, combinations; Foot, expanding, cylindrical, contracting, combinations; Feet (in case of more than one foot) variations different.

Handles: Differentiated by (1) number; (2) position on vessel: (*a*) body; (*b*) neck; (*c*) foot; (*d*) combinations.

Form : (*a*) continuous with body or neck, (*b*) not continuous with body or neck, (*c*) with constant direction, (*d*) with varying direction, (*e*) with re-entry upon vessel. A′ Round, B′ Flat, C′ Coiled.

This is not all of the classification, but probably sufficient to give an idea of its main principles.

5. *The Ancient Frescoes at Chichen Itza.* *By* Miss A. C. Breton.

The ruins of Chichen Itza in Yucatan are amongst the most important in Central America, being especially remarkable for the number of coloured portrait sculptures and frescoed walls. The frescoes have been sadly destroyed in the course of centuries, but enough remain to provide striking pictures of the life of the ancient folk. In two of the upper rooms of the building called the Nuns' Palace, the walls and vaulted ceiling were entirely covered with scenes which had backgrounds with thatched houses and trees, also temples with high-pitched roofs enclosed within battlemented walls. There were groups of warriors armed with spears, *atlatls* (throwing sticks), and round shields, and others seated on the ground, with ornamental tails hanging from their girdles. The drawing was firm and spirited, the colouring vivid and harmonious.

Stephens observed a row of Maya glyphs painted just below the vaulting in the interior of the small building known as the Iglesia, but they have disappeared, and there are no signs of any glyphs among the paintings at Chichen Itza. The chambers of the Akaboib have been whitewashed in modern times, and only a blue band along the edge of the vault is now visible. In the narrow corridor of the Caracol, too, very little colour is left.

The building at the south end of the eastern wall of the great Ball Court, usually called Temple of the Tigers, contains in its upper part the best-preserved paintings yet discovered. The outer chamber having been filled with débris owing to the fall of the roof when the wooden lintels gave way, the inner chamber also became partly blocked and difficult of access, until Dr. Le Plongeon in 1884 cleared away most of the accumulated material, and partly copied the paintings in it. Visitors wrote their names over the frescoes, bats lived at one end; swallows at the other, and bees made tunnels in the plaster. Still it has been possible to secure many of the details and to give some idea of the composition. The chamber is about 26 feet long, and not quite 8 feet wide, and 22 feet high to the top of the vault, with the door in the middle of the long western side. Each of the long sides is divided into three panels, of which the four end ones represent landscapes full of armed warriors, as do those of the north and south sides, with houses above, and tents and temporary buildings below, where chiefs are consulting and priests perform rites of divination. These panels are divided by a blue band from a dado with mythological figures and plants.

The south-west end is the most complete, and has about 120 figures, almost all of them placed at certain distances and angles from each other. These distances were measured from the point where the nose of each figure appears above the shield, and form the basis of the composition. The position of the shields fixed, the artist then drew the figures according to his fancy, and no two are alike. In this scene the attacking party are distinguished from the defenders of the village above by a difference in costume. The former have cotton knee, and ankle bands, small green shields at their backs with hanging streamers, and round green earrings and necklaces. Their headdresses, surmounted by long feathers, are more elaborate than those of the villagers. The latter have a round, stiff headpiece with two or three blue feathers standing up from it, oblong ear ornaments which pass through the elongated lobes, white shirts and round shields, usually with a crescent in the centre as device. All cast their spears from *atlatls*. The chiefs, who sit in consultation below, have feather mantles like those of the portrait statues which supported the sculptured table in the outer chamber.

The narrow south end panel also has a scene of attack, with high scaffold towers and a ladder of a notched tree-trunk, on which some of the assailants are perched. Here the men are taller and more athletic than in the previous scene. In the following panel there are more important houses, forming a town, with a forest on both sides, in which are animals, snakes, and birds. Beyond come

the Red Hills on which wilder figures are grouped, with rocks and trees below. The north end is much destroyed, but some personages on a background of blue sky may represent departed heroes. The shields in this are oblong. The last of these scenes shows a group of houses inside a defensive barrier, and blue warriors in feather cloaks have conquered the inhabitants. Above the door a life-size recumbent figure may be the hero in whose honour the building was erected.

6. *Archæology in Peru.* *By* Miss A. C. Breton.

In recent years there has been much activity in the field of Peruvian archæology. At Tiahuanaco (which must always be associated with Peru, though now within the borders of Bolivia), M. G. Courtz, of the expedition of MM. Sénéchal Lagrange and de Créqui-Montfort in 1903, excavated the wide monolithic stairway which forms the eastern entrance to the great enclosure called Kalasasaya. He then dug along the western line of monoliths, and found that they were connected by a wall of cut stone. On that side he uncovered the double walls of another enclosure, and to the east he found a smaller one, constructed in similar style to the Kalasasaya, with upright monoliths at almost equal distances from each other, and a connecting wall of smaller squared stones, uncemented. From this wall projected a number of human heads, carved in the round from trachyte, and apparently portraits. Some of them are now in the Museum at La Paz. In 1910 the Bolivian Government had the Puerta del Sol set upright and cemented, and erected a shelter for the many sculptured stones which had been found. An underground chamber of carefully cut and fitted stone, discovered in 1908, is only 1 m. 40 cm. by 1 m. 30 cm. (not including five steps which lead down to it), and 1 m. 83 cm. high. The roof is of flat slabs of andesitic lava. Five colossal statues have been disinterred, of which the largest is 5 m. 72 cm. high. They are covered with finely incised designs. On the breast of one is a figure of the deity represented in the centre of the Puerta del Sol, surrounded in this case by standing personages. Another has several minute faces on its hands, and a face on each finger-nail.

Small portions of the great pyramid-building Ak-kapana can be seen---terrace walls of well-cut stone, but the masses of earth thrown out from the excavation of the centre (the present hollow is said to be more than 300 feet in diameter and 60 feet deep) hide the greater part. At Pumapanku, on the opposite side of the Indian town, a number of huge blocks of stone remain at the edge of the plateau. Although many hundreds of tons of worked stones have been removed from the ruins for different purposes, there is no doubt that systematic excavation, conducted by competent persons, would result in discoveries of the greatest interest. It is a mistake to suppose that because Tiahuanaco is at the altitude of 12,000 feet, the climate is too frigid for comfort. In the middle of winter there the early mornings are cold, and frost may lie in the shade all day, but the sun is hot and the air invigorating. Plentiful crops of barley are gathered, besides the native quinoa and potatoes, and the Indians are well nourished and clothed, capable of long journeys with their lamas and other animals. On St. Peter's Day they assemble in thousands to perform their ancient dances in the town square, as described by Squier. A curious feature is that those who wear great feather crowns resembling the tops of palms, after dancing for some hours, place them in the centre of the ring and continue to dance round, bending towards the crowns as if in worship.

The amazing richness of Peru in antiquities is seen in the galleries of the National Museum at Lima, which Dr. Max Uhle has filled with the results of two years' excavation in the region of Nazca, the neighbourhood of Lima, and near Trujillo, all coast civilisations. In the bay of Ancon, the first settlements of primitive fishermen were on the side hills which slope to the sea, where the rocks are covered with shellfish. Then followed the wide-spreading town which filled the sandy area between sea and mountains, known from Reiss and Stübel's book as the Necropolis of Ancon, but now proved to have been a series of shell heaps and of reed huts, which decayed or were destroyed after the owners had been buried under them with their possessions, when others were built above. The accumulated material covers a space more than a mile square and 30 feet

high. The graves are small pits lined with pebbles. Dr. Uhle spent several years in excavating at Pachacamac for the University of Pennsylvania, and has been able to form some idea of the sequence of the different kinds of pottery from his finds there and in other places. The beautiful painted pottery at Ica and Nazca proves to be earlier on the coast than any other, and the primitive fishermen learned the art of vase-painting from the proto-Nazca folk. Richly clothed mummies, feather garments of symbolic design, mosaic ear-plugs, gold and silver cups, and a cuirass covered with small metal plates, are some of the treasures of the Lima Museum.

Of the remoter Stone Age little is yet known in Peru, but chips and scrapers are found in the alluvium on the plain of Lima, and the deposit with fragments of rude pottery, observed by Darwin, can still be seen on the top of the cliff near Bellavista.

FRIDAY, SEPTEMBER 1.

Discussion on Totemism.

(i) *The Present Position of our Knowledge of Totemism.*
By DR. A. C. HADDON, *F.R.S.*

(ii) *An Interpretation of Totemism. By* DR. A. A. GOLDENWEISER.

Totemic phenomena, in America and elsewhere, may be looked at from the point of view either of the various ethnic features, such as exogamy, totemic tabu, myths of descent, &c., or of the social organisations of the totemic communities in their entirety.

All the various individual features of totemism occur within as well as without totemic complexes, and their psychological character as well as their genetic derivation display great variability. Exogamous clans are found in non-totemic communities, while the totemic clans of the Nandi and Taveta do not practise exogamy. Moreover, by exogamy may be meant clan exogamy or local exogamy, or that type of marriage regulation which depends on relationship, actual or assumed. Exogamy is also in many ways correlated with endogamy, and neither can be properly understood without the other. Further, the origins of the various types of marriage regulations may be manifold.

The case of the totemic name is in no way different: thus animal names are found among the non-totemic bands and the religious societies of many tribes in North America, while many of the Omaha totemic clans do not derive their names from their totems. Nor can it be maintained that non-eponymous totems and local names are associated exclusively with paternal descent; for the paternal Baganda derive their names from one set of their totems, while the clans of the maternal Tlingit and Haida, and the families of the Tsimshian, have local names. Maternal descent, again, cannot be made one of the 'symptoms' of totemism. Tabus on animals and plants are scattered far and wide, beyond the limits of totemic clans. Tabus are associated with pregnancy, initiation, mourning, age groups, hunting; with sacred animals, such as snakes in India or cats in Egypt; with the guardian animal of the American Indian. On the other hand, the totemic animal is not always tabu. At all times and among many people we find the belief in descent of man or men from beast. The beast need not be a totem. The totem, in its turn, need not be the ancestor.

It would be possible to treat in a similar way the belief in a spiritual or vital relationship between clansmen and totems, reincarnation beliefs, magical ceremonies, various types of initiation ceremonies, &c. It follows that all attempts to characterise totemism by a more or less definite set of features must needs be artificial. Consequently the distinctive characteristics of totemism are not the individual features, but the relation into which they enter. The problem is one of secondary association.

In all totemic communities we find a differentiation of a group into definite

social units—clans—which are distinguished by a set of homologous features, different in specific content, but identical in form. These features may be few or many, and include clan and individual names, spiritual beliefs, myths, rituals, material possessions, songs, dances, social regulations, prerogatives, &c. In a vast majority of cases these features are hereditary in the clan and form a totemic complex. Before ethnologists can progress much further in the investigation of totemic phenomena, a most careful analysis of the content and nature of totemic complexes becomes imperative.

The problems involved are manifold. In the totemic complex there is considerable variability, both as to the number and the character of the individual features. It is necessary to attempt to reconstruct the process of the association of these various features, and of their socialisation within the limits of each one of a number of definite and similar social units. The mutual relation of the features at any given period in the development of the groups is another problem. A preliminary survey of the data discloses a tendency of one or another or some few features to assume a central position in the complex, thus lending a specific colouring to the entire culture of the group. Among the tribes of the North-West Coast of America the cycle of ideas associated with the guardian spirit and the representation of totemic animals in art have become such dominant features. Among some Bantu tribes of Africa, on the other hand, two features of a very different order seem to occupy an equally prominent position. These are the tabu on the totem, and property rights in land associated with totemic clans. The totemic complexes of Central Australia, again, centre around the magical ceremonies for the propagation of totems, and the beliefs of the natives in a spiritual connection between the clansmen and their totemic ancestors.

The specific functions carried by the various social units embraced in a totemic complex also claim our attention. The clan of the Haida or Tlingit, the clan of the Iroquois, the clan of the Aranda, differ vastly in their functions as well as in their positions in the social organisations of the several groups. The North-West Coast clan holds the exclusive right to certain ceremonies, names, myths; it owns material property, hunting and fishing districts; the clans of this area, moreover, differ in social rank. The Iroquois clans do not own property(?), they do not differ in rank, but they exercise political functions which are utterly foreign to the clans of the North-West Coast. Among the Aranda, the clansmen are held together by little else than common ceremonies and spiritual beliefs. In contrast to all these, some of the Baganda clans have assumed the character of professional classes, a characteristic commonly identified with social units of a totally different order, the castes of India. As to the relative importance of the clans in their respective social organisations, witness the contrast between the North-West Coast of America, where the sharply defined clans practically carry the entire culture of the group, and the tribes of Central Australia, where the clan is a loose social aggregate with naught but common ceremonies and spiritual beliefs to determine its solidarity.

Finally, the most fundamental, and in a sense the most significant, problem of all is an intensive analytical and synthetic interpretation of the entire set of socio-psychological conditions which make possible the appearance of phenomena such as totemism. Of the possible results of such a study we have but the faintest adumbration.

(iii) *Totemism as a Cultural Entity.* *By* DR. F. GRAEBNER.

Every attempt to account for the origin of totemism must first deal with the question whether this institution is a cultural entity, for if it be once conceded that the forms of totemism found in different parts of the earth have arisen independently there can be no justification for the assumption that it has had everywhere the same origin.

In the South Seas there are two wholly different social systems : (*a*) totemic local exogamy with patrilineal descent, and (*b*) the arrangement in two exogamous classes with matrilineal descent which, so far as locality is concerned, is often endogamous. I have shown that these belong to two quite different cultures, and that any intermediate forms are the result of contact and mixture.

The same holds good for other regions. In Africa local totemism with patrilineal descent is associated with cultural elements allied to those of the

totemic culture of the South Seas, a secondary form with certain definite characters having been carried by a pastoral people into South Africa. In West Africa there is a different culture allied to the matrilineal cultures of the South Seas, and wherever the totemic culture has come into contact with it we find that the totemism has taken on matrilineal descent, though in a form different from that of the South Seas.

In South America the older totemic form is to be found in the western region of the Amazon; in North America it is present in the majority of the Algonkin, while in the North-West local totemism can also be recognised as the older form. The cultures of those regions with matrilineal totemism are again related to the matrilineal cultures of the South Seas.

Since the same relations also hold good in Asia, I believe the position of group-totemism as a cultural entity wherever it is found to be established. Whether the so-called individual totemism and sex totemism belong to the same culture as group-totemism is not so clear. Even if it were so, however, group-totemism could not have arisen from individual totemism, for, apart from other difficulties, individual totemism is too weakly developed in the older regions of the totemic culture. There is no older condition from which group-totemism can be derived. Its explanation must be sought in its own characters. The older form is that in which the totems are animals. In this form there is an indefinite and unstable relation of sympathy between man and beast which can be explained simply by certain groups of men and animals having coexisted locally in a region of diversified physical characters.

(iv) *On the Relations between Totemic Clans and Secret Societies.*

By Professor HUTTON WEBSTER.

The esoteric associations found among aboriginal peoples may be conveniently described as secret societies, though this appellation covers a wide range of ethnic phenomena not easily brought within the confines of a single definition. The many remarkable similarities characterising secret societies in widely separated regions must be assumed to have had an independent origin; nevertheless, an intensive study of cultural areas will probably disclose a vast amount of borrowing between related peoples. Comparative studies of the technique of masks and costumes, together with a systematic analysis of initiatory rituals, should clear up many puzzling problems of diffusion.

To outside observation the judicial and political functions of the secret societies appeared their most impressive feature, and quite naturally were the first to attract attention. In West Africa and Melanesia, particularly, they punish criminals, act as the native police, collect debts, protect private property, and, where they extend over a wide area, help to maintain intertribal amity. Such secret societies are more or less limited in membership, are divided into degrees through which candidates able to pay the cost of initiation may progress, and are generally localised in some lodge where the initiates resort for their ceremonies. The use of masks, bull-roarers, and other devices serves to indicate the relationship of the members with spiritual beings and to terrify those not admitted into the mysteries. In spite of the great evils often attaching to these bodies, we are permitted to see in them one of the most significant forms of primitive social institutions.

But it would be a vital error to infer that secret societies of this type were consciously devised to preserve law and order in a savage community. Further investigation reveals the singularly important part played by many of them in the conduct of funereal rites and especially of initiation ceremonies at puberty. Under their direction the youth is removed from defiling contact with women, subjected to numerous ordeals, instructed in all matters of religion, morality, and traditional lore, provided with a new name, and given new privileges—in a word, made a man. Puberty rites of this nature may be best studied in Australia, but are also characteristic of many Melanesian and African secret orders. It is not impossible to reconstruct, at least in outline, the steps whereby the rude but powerful aristocracy of a secret society may have emerged from a more democratic association which enrolled in its ranks every male and adult member of the community.

There is, however, another aspect of primitive secret societies, very prominent in the fraternities of American Indians, but hitherto not sufficiently emphasised in the discussion of related organisations elsewhere. The initiates constitute a theatrical *troupe*, with masked and costumed actors personating animals, and presenting songs, dances, and pageants, which together form a vivid dramatisation of legendary history. Ancestor-worship and the cult of the dead loom large in their rituals. Ceremonies undoubtedly magical in character, such as rain making and sorcery, the preparation of charms and spells, and the cure of disease belong to many of the organisations.

These and other features of developed secret societies appear to be closely connected with the structure and functions of totemic clans. The formation of tribal aggregates from clans would gradually bring about a transference, partial or complete, of characteristic clan rites—initiatory, funereal, magico-religious, and dramatic—from the clan to the larger community of initiated men, and thence, in many instances, to esoteric associations of limited membership. Accordingly, the secret societies of primitive peoples would represent one of the results of the disintegration of the ancient totemic groupings. A study of various areas should disclose how this process of development has worked out in different environments and under the stress of diverse circumstances.

(v) *Some Methodological Remarks on Totemism.*
By Professor E. WAXWEILER.[1]

Light can only be thrown on the question of so-called totemism by the application of a scrupulously accurate method of analysis. That method should be mainly *sociological*—i.e., it should consider the so-called totemic facts as being imposed by the conditions of organised social life amongst men. Further, its starting-point should be 'functional'; it must search for the *social function* from which totemism has sprung. It follows that.—

(*a*) It is out of the question to discuss 'forms' and the typical character or purity of forms[2] of totemism or to represent this or that form as a trace of an anterior form, more or less complete;

(*b*) it is improper to build up an *evolution of totemism* as such: a social function displays itself just as it can, according to the social conditions of the individuals whose organisation this function realises;

(*c*) the investigation of the social function that totemism performs should extend to civilised as well as to primitive societies; where the function is not traceable in civilised societies, or where it appears otherwise than in a primitive society, the causes of this change should be detected.

As first results of those principles, it may be shown that totemism is 'functionally' independent of: (*a*) religion, (*b*) exogamy so-called, (*c*) ancestral descent, (*d*) relationship of individuals with their totem, (*e*) social interdicts (tabus), (*f*) name of the totemic group, (*g*) protecting or serviceable character of the totem, and (*h*) representative emblems of the totem. These are all merely 'symptoms,'[3] and do not appear as distinctive features of totemism, as is commonly contended.

As a second result of the application of those principles, the following interpretation of totemism might be suggested: That functionally totemism is a social device for *sanctioning permanent situations wherein individuals, or more frequently groups of individuals, appear to remain and which are considered as essential or peculiar in the organisation of the group.*

To create such a sanction in primitive society, a very simple and altogether very efficient method seems to have been (*a*) to 'vow' the group to one *well-known and familiar thing* (animal, plant, object)—that condition being of course necessary, for it makes the occasions of sanctioning numerous—or even to more than one thing;[4] (*b*) simultaneously to associate with those things, positively or

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[1] I have to thank Miss Nadine Ivanitzky for her assistance in the preparation of this note.

[2] *Cf.* Rivers, *Jour. Anthrop. Inst.*, 1909, p. 156.

[3] Comp. Goldenweiser, *Totemism, an Analytical Study,* p. 182 and *passim.*

[4] Comp. Wolf, *Anthropos*, 1911, pp. 451 and *seq.*

negatively, *social attitudes*, very simple and frequent, on grounds entirely fanciful and not a bit rational. This functional method of social sanctioning might be called *totemism.*

One of the collective situations that seem most frequently to need sanction is the permanence of a social grouping *whatever its origins and whatever its special field may be* (for instance, blood—or fictive relationship extending over generations, hereditary castes, &c.). The occasionally emblematic, as well as the occasionally traditional character of the totem would simply appear to be consequences of the original sanction, the symbol being a means of social attestation and the hereditary transmission a means of social continuity. Totemic tales would be *post facto* explanations elaborated according to a well-known social process.

The totemic function would in primitive society be naturally mingled with the manifestations of several other functions, as is the case for every function in the complex of organised social life: so it would come to appear as interwoven with, for instance, the regulation of marriages, or with tabus, &c.

Totemism, as so interpreted, would spontaneously tend to disappear in every society that would allow more practical and surer administrative devices to be applied in order to perform the same function as totemism performed in primitive society.

The following Paper was then read :—

The Tribes of the Mimika District of Dutch New Guinea, the Tribes of the Sea Coast, and the Tapiro Pygmies. By Captain C. G. Rawling.

MONDAY, SEPTEMBER 4.

The following Papers and Reports were read :—

1. *Notes on the Stature, &c., of our Ancestors in East Yorkshire.*
By the late J. R. Mortimer.

During the author's excavations of over three hundred burial-mounds and cemeteries in East Yorkshire during the past half-century, he gathered together a fine series of crania and other bones belonging to the Neolithic, Bronze, Early Iron, Romano-British, and Anglo-Saxon periods. Of the Neolithic and Bronze periods remains of 893 bodies were obtained, but as 322 of these had been cremated, 571 only were available for detailed measurements. Of these, 35 were long-headed and had an average stature of 66 inches, 29 had short skulls and averaged 64·3 inches in height, and 40 had skulls of an intermediate form and averaged 64·4 inches in height. The greatest stature in this series measures 72·8 inches, and the lowest 56·4 inches.

During the Early Iron Age the inhabitants possessed more uniformly long skulls, but were physically much inferior to their predecessors. Of 59 skeletons, 42 had long heads and an average stature of 62·5 inches, 2 had short heads with a computed height of 61·9 inches, while 14 were intermediate in type and averaged 63·2 inches. The skeletons of the Romano-British period were not so plentiful, but much resembled those of the Early Iron Age, from which they probably descended.

Of the 61 Anglo-Saxon skeletons measured, 31 had long heads, with an average stature of 65·7 inches; seven had short heads with an average stature of 64 inches, and 23 had skulls of an intermediate type, and had an average stature of 63·6 inches.

Taking the Anglo-Saxon skeletons in their entirety we find that they average 3·4 inches in height greater than their predecessors of the Early Iron Age, though they more nearly resemble the people of the Stone and Bronze periods. From the evidence given it is clear that the first inhabitants of this district

were people of a mixed race, and quite as dissimilar from each other as are the people occupying the district to-day. Of East Yorkshire it can certainly not be said that a purely long-headed or short-headed race first occupied the district.

2. *The Interpretation of Division of the Parietal Bone as observed in the Crania of certain Primates. By* Professor C. J. PATTEN, *Sc.D.*

Of recent years several specimens of the crania of primates illustrating division of the parietals have been observed and figured. With the aid of such, coupled with a diligent inquiry into the development of the human parietal bone, our knowledge on the subject has no doubt considerably increased; but it seems that unless we can get further evidence from the condition of the contained brain we are much handicapped in attempting to put forward an interpretation as to the causes of parietal division. This is especially so where in the dry skull pathological conditions (perhaps at an earlier stage of development more apparent) are only faintly discernible, and where they may be said to have passed almost without a line of demarcation into what one might conveniently term a condition of disturbed *morphogenesis.* However, as many specimens of dry skulls, *minus* their brains, recently examined afford fairly positive evidence of an abnormal process of development, the trend of opinion is that the supposed morphological significance assigned to the segments of divided parietals, together with the supposed atavistic value attached to the same segments, are hypotheses which are losing ground.

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3. *Suggestions for an Imperial Bureau of Anthropology.*

(i) *Anthropometry. By* JOHN GRAY, *B.Sc.*

The Royal Anthropological Institute presented to the members of the last Imperial Conference a memorial asking for their support in the establishment of an Imperial Bureau of Anthropology. The object of this Bureau would be to direct and control the collection and collation of important data about the physical and mental characters of the many races living within the confines of the British Empire. The constitution of the Bureau would be representative.

The rapid progress of industrialism is producing profound changes in the conditions of life of the great mass of our population. During the last fifty years the whole increase of our population has been absorbed by our great towns and cities. A great increase has taken place in the employment of women in factories and in business which will injuriously affect the natural vigour and upbringing of the children of succeeding generations.

Notwithstanding the occurrence of these vital changes in the national physique, we have no institution for taking stock periodically of the physical and mental characters of the people. Such an institution was recommended by the Physical Deterioration Committee in 1903, and has received the approval of the leading statesmen of all parties, but has not yet received any financial support. Germany, Denmark, the United States, and other countries have adopted many of the recommendations of the scientists of this country; in Great Britain their value has yet to be fully recognised.

(ii) *Ethnography. By* T. C. HODSON.

The author began by giving instances of Government action with regard to Ethnographic Surveys, citing, amongst others, the inauguration of the Ethnographical Survey of India, of the survey of the tribes of Assam, the work done by Dr. Seligmann for the Governments of Ceylon and the Sudan, and the survey recently undertaken by the Canadian Government as the outcome of representations made by the British Association.

But in all these, admirable though they are, there is lacking the essential of unity of purpose and method. It is to provide this unity of purpose and method, to stimulate constantly the attention of Government Departments, and

to bring into focus all the energy that is available for such work, that the Council of the Royal Anthropological Institute has endeavoured, and is endeavouring, to organise an Imperial Bureau of Anthropology.

The purposes which such a Bureau would serve may be summarised as follows:—

(i) The formulation of standard methods of anthropological and anthropometrical investigation.

(ii) To assist Government Departments, private bodies and individuals with expert advice, wherever any new anthropological investigations are undertaken or are in contemplation, to indicate areas where such investigations can be profitably conducted, and to assist in their organisation.

(iii) To communicate directly, or through local committees, with active workers in the field, to assist them with information as to the progress of similar investigations elsewhere, and as to the results of previous investigations whenever an area is re-surveyed.

(iv) To collate and to publish in standard form the reports of investigators and the numerous anthropological data received from time to time at the Royal Anthropological Institute from its many local correspondents throughout the Empire, to distribute such publications to the various Governments and Government Departments concerned, and to public and private bodies and persons engaged in anthropological investigation.

(v) To publish periodical reports, under competent editorship, dealing with the progress of anthropological knowledge and of anthropometry, which would be capable of collation into the decennial Census reports.

4. *Suggestions for an Anthropological Survey of the British Isles.*

By H. PEAKE.

The influence of anthropology on the study of history has been to demonstrate that the course of human actions has been, to a great extent, controlled by geographical conditions. This has led to a demand for maps illustrating the connection between man and his environment, but such maps cannot be made with sufficient accuracy until a preliminary survey has been undertaken. This paper advocated a survey of the British Isles on these lines, and the production of a number of maps on the 1-inch scale, accompanied by memoirs illustrating all phases of human activity, or conditions by which they may have been influenced.

It is proposed that a society should be formed, governed by a council consisting of the principal experts in the various subjects to be dealt with, and that the country be divided into a number of districts, or geographical units, each containing about two hundred square miles. That in each unit a registrar be appointed, to co-ordinate the work in that area, and that those engaged in research be encouraged to compile maps and memoirs, either of one unit from several points of view, or of several contiguous units from one point of view. That the country be divided eventually into several large natural regions, consisting of several counties, and that when all the maps and memoirs relating to one particular subject in all the units of a region have been completed, a monograph should be published, in which the work of all contributors should be acknowledged.

The scheme, to be successful, requires the sympathy and assistance of the learned societies interested in such subjects, besides the help of those who are engaged in such lines of research. It will be a continuation of the work carried out by the Geological Survey, and of the regional monographs compiled under the auspices of the Royal Geographical Society.

5. *Report on the Organisation of Anthropometric Investigation in the British Isles.*—See Reports, p. 130.

6. *Dolmens or Cromlechs.* *By* A. L. LEWIS.

A comparison of a large number of dolmens and other rude stone monuments shows differences of construction and apparently of purpose. Some of these differences are localised. Taking these points into consideration, together with the vast area over which the rude stone monuments extend, and their great numbers, it is probable that they were not the work of a single race, which went about the world constructing them; nor of two races, of which one erected the dolmens and the other set up the circles, but that they were part of a phase of culture through which many races have passed. Little if anything can be deduced from these monuments as to early migrations of the human race.

7. *Report on the Distribution of Artificial Islands in the Lochs of the Highlands of Scotland.*—See Reports, p. 137.

TUESDAY, SEPTEMBER 5.

The following Papers were read:—

1. *Some Religious Beliefs of the Kikuyu and Kamba People.*[1]

By C. W. HOBLEY, *C.M.G.*

It is probably hardly necessary to mention that the A-Kikuyu and the A-Kamba are two of the best known and important tribes in the interior of British East Africa, and together number well-nigh a million souls. The observations recorded in this paper were obtained from direct contact with the tribes in question and particularly from their chiefs and elders.

In the last number of the 'Journ. R. Anthrop. Inst.' the author published a paper on certain aspects of the subject of the present paper, with particular reference to a phenomenon called *thahu*, *nzahu*, or *thabu*, and it is necessary to refer to that in order to make quite clear some of the present research.

The term *thahu* may be described as a condition which is the result of a curse in the mediæval sense; it is a condition into which a person may fall if he or she commits certain forbidden acts, breaks certain prohibitions, or again it may be the result of certain circumstances over which the victim has no control. Some sixty different examples of the way in which *thahu* can be incurred were given in the paper referred to. One important fact to be remembered is that the incidence of any particular *thahu* often depends upon the circumcision guild to which the person belongs. This line of investigation was found to open such a large field of inquiry, and to give such an insight into a side of native life which usually escapes notice, that it has been continued and extended in the present paper. One interesting feature now elucidated is another form of curse, called a *Kirume*, which can be inflicted by a dying man, the general idea being that a dying person can lay a curse upon property belonging to him or can lay a curse upon another person, but only upon a member of his own family. For example, the head of a village can lay a curse upon a plot of land and lay down that it is not to pass out of the family or dire results will ensue. This would appear to be of considerable interest as being the early stage of a last will or testament, and moreover, the rude beginning of the principle of 'entail.' It may further be taken as some evidence of individual tenure in land.

In some cases the *thahu* curse affects the hut; this appears to be worthy of note, as it may in some measure account for the low type of domestic architecture among many of the Central African tribes, for it becomes obvious that there is but little incentive to build large permanent structures if there is a possibility

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[1] To be published in full in *Journ. R. Anthrop. Inst.*

that the owner may have to demolish his dwelling-place at short notice owing to the incidence of a *thahu* or curse.

The question of the members of the tribe who are qualified to remove the effects of these curses has been carefully examined, as, apart from the practical value of such investigation, it may throw some light upon the evolution of the priestly function among primitive peoples.

The ceremonial which takes place on the occasion of a death has also been carefully investigated, as it does not appear to have been fully inquired into before, and it shows how closely the Kikuyu tribesman is bound down by the ritual of the guild to which he belongs from early years up to death.

Another important phase of native life is the procedure which has to be adopted in the case of a murder, for unless the proper observances are carried out the crime of homicide is likely to create an hereditary feud between the two families which will eventually lead to further bloodshed, and until the ceremonial has been completed, no member of the murdered man's family can eat food out of the same dish or drink beer with a member of the family of the murderer. It has been discovered that the power of the 'Evil Eye,' which is so widespread in South Europe, extends to Kikuyu and Ukamba. Certain people in the tribes are believed to be born with it; they can, however, neutralise its evil effects by ceremonially spitting upon the object supposed to be afflicted or to be in danger.

One clan of the Kikuyu tribe, called the Ethaga, are supposed to possess magical powers; in fact, they are classed as a family of wizards. Some are supposed to have power over the rain; others can kill people with their magic, can lay a curse upon a thief, and can place spells upon patches of forest to prevent people from cutting them down.

In travelling through Kikuyu one will occasionally meet a young man carrying a rattle made of a gourd ornamented with cowries and inscribed with devices; the owners sing songs about the devices on these gourds. The singer commences to sing about the design at the lower end of the gourd, and gradually works his way through the various patterns, singing a verse about each. If he makes three mistakes and his accuracy of the interpretation of the pictographs is challenged, his gourd becomes forfeit to the challenger. The translation of these songs and the interpretation of the devices are of interest, as they possibly illustrate the dawn of the ideograph.

2. *The Economic Function of the Intichiuma Ceremonies.*

By B. MALINOWSKI.

The way in which man works at a low level of culture differs essentially from economically productive labour in psychological conditions. Economic labour must be systematic, continuous, or periodic; it requires forethought and presupposes organisation. The attitude of savage man at work approaches much more nearly that of our play or sport, and does not in general give rise to the qualities essential to economic labour owing to the feeble development of certain psychological factors, such as self-constraint, attention, intellectual and volitional effort. In all cases in which the savage endures continued exertion, as in war, the dance, hunting, and some highly skilful and elaborate technical achievements, certain elements (play, excitement, ecstasy, intoxication, rhythm) can be pointed out which act as stimuli and either supersede or render unnecessary free volitional effort.[1]

If we examine the Intichiuma ceremonies of the Arunta tribe (and some of the other tribes of Central Australia) we find that the work accomplished in these ceremonies presents a highly economic aspect—in the sense just explained—if the general level of culture in the said tribes be taken into account. This work is the result of collective and organised activity, as it is performed by the local group as a body under the lead of the alatunja or headman. It is to a certain extent regular and periodic, and connected with the seasons; it always evidences

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[1] For a fuller treatment of the subject and examples *cf.* K. Buecher, 'Entstehung der Volkswirtschaft,' and 'Arbeit und Rhythmus'; and G. Ferrero, 'Les formes primitives du travail,' in *Rev. Scient.*, 4ᵉ ser., vol. v., 1896, pp. 331 and *seq.*

forethought, and in certain cases it has a definite practical object. Taking all these characteristics as a whole, these ceremonies reveal a more distinctly economic form of labour than any other which is found among these tribes, especially if compared with their methods of collecting food, hunting, and other practical occupations.

It is a remarkable fact that the most highly developed form of labour in these tribes is found in connection with totemic ceremonies. According to the general remarks made at the outset, it is necessary to show that in these ceremonies there are some mental factors acting as substitutes for the free volitional effort which is required by real economic activity. As a matter of fact, the totemic ideas which organise and regulate the labour in question possess, as a signal characteristic, an irresistible ascendency over the primitive mind, and that accounts for man being compelled under their influence to work in a manner for which he has a natural reluctance. It is this specific character of necessity, constraint, and compulsion that Professor Durckheim regards as a distinctive feature of religious phenomena. This binding power of religious ideas is put in bold relief in the ceremonies under consideration, and it is evident that the connection between economic and magical or religious ideas, such as is found in the Intichiuma ceremonies, is not superficial and accidental, but deeply rooted in the essential qualities of these two classes of fact. We thus see how the totemic ideas, without leading to real economic enterprise, educate society to a kind of labour capable of economic utilisation. It is a question whether this educational influence may not be of wide application; in other words, whether magical and religious ideas have not played an important part in the evolution of economic labour. The comparison of the Intichiuma ceremonies in the different tribes described by Spencer and Gillen to a certain extent seems to confirm this view, if it be assumed that there is a progressive development from north to south. In the northern tribes (*e.g.*, Warramunga) they are purely traditional and representative ceremonies, and possess almost no influence upon the multiplication of the totemic animals or plants; in the more southern tribes this latter aim becomes more prominent, and in the Arunta they are applied to direct practical ends. Moreover, the work done in the Warramunga falls almost exclusively upon the headman, whereas it is more collective in the Arunta and other kindred tribes. Thus the economic aspect becomes more and more pronounced as we advance southwards.

3. *The Divine Kings of the Shilluk.* *By* C. G. SELIGMANN, *M.D.*

The Shilluk kings trace their origin to Nyakang, the semi-divine hero who, with a comparatively small band of followers, took possession of the present Shilluk territory and founded the Shilluk nation. The genealogy of the royal family shows that twenty kings belonging to twelve generations intervene between Nyakang and Kwadke, the first king to be killed by the Turks.

The majority of Shilluk think of Nyakang as having been human in form and in physical qualities (though, unlike his more recent successors, he did not die but disappeared), but there are also legends of his descent from a crocodile maiden. The holiness of Nyakang is especially shown in his relation to Juok, the formless and invisible high-god of the Shilluk, who made men and is responsible for the order of things; for it is only through Nyakang that men can approach Juok, performing the sacrifices to Nyakang that cause him to move Juok to send rain.

Nyakang manifests himself in certain animals, as do the spirits of the dead Shilluk kings, who from one point of view are considered identical with Nyakang, for they incarnate his divine spirit. This belief appears to have led to the ceremonial slaying of the king when he becomes ill or senile, lest with his diminishing vigour the cattle should sicken and fail to bear their increase, the crops should rot in the fields, and man, stricken with disease, should die in ever-increasing numbers.

4. *The Foreign Relations and Influence of the Egyptians under the Ancient Empire.*[1] *By* G. Elliot Smith, *M.A., M.D., F.R.S.*

In a previous communication[2] attention was called to the fact that the population of Lower Egypt had received a strong infusion of alien blood before the time of the earliest Pyramid-builders. During the past year much more precise evidence has been obtained concerning these foreigners in Egypt and the distribution of their kinsmen beyond its frontiers; and in the process of following these people in Western Asia and North Africa much information has been obtained, which seems to be complementary to that obtained by historical research in Europe and a solvent of many of the apparently insuperable difficulties that have beset archæologists working in the Mediterranean area.

The aliens who mingled with the Proto-Egyptians in the early centuries of the third millennium B.C. were in large part the kinsmen of the people variously called 'Armenoid,' 'Alpine,' 'Celtic,' &c., who are said to have introduced the culture of the Bronze Age into Europe. Thus the early history of Egypt is brought into co-relation with the great events that ended the Age of Stone in Europe and Western Asia.

The people of Upper Egypt discovered copper in early Predynastic times, and during the succeeding centuries slowly learned to appreciate the magnitude of their discovery. In late Predynastic times they were casting formidable metal weapons, which enabled them to unite the whole of Egypt under their sway. They pushed their way beyond the frontiers of Egypt, as they tell us in their own records—to Sinai for copper-ore, and to Syria for cedar from the Lebanons, as well as to the south—and they met and intermingled with the Armenoid population of Northern Syria, who acquired from them the knowledge of copper and its uses, while the Egyptians themselves took back into Egypt, in their own persons, ample evidence of the existence of an Armenoid population in Syria before 2800 B.C.

Before this time the Armenoids had been trickling into Neolithic Europe, without, however, making much impression upon the customs or the physical traits of its population; but once they had acquired metal weapons from the Egyptians they were able to make their way into Europe by force and to impose their customs upon her people, in virtue both of their numerical strength and the power they wielded from being better armed.

In Egypt itself the Proto-Egyptians in Predynastic times had learned to make not only weapons of war but also tools of copper. The skill they acquired in using these tools made them expert carpenters and stonemasons; and during the early dynasties they ran riot in stone, creating the vastest monuments that the world has ever seen The knowledge of these achievements spread amongst the kindred peoples on the southern shores of the Mediterranean, to the neighbouring isles, and to Southern Italy and the Iberian Peninsula. But it was the knowledge of the various kinds of monuments that the Egyptians were building, and not the skill nor the skilled workmen that spread : at the time of the Sixth Dynasty, or thereabouts, the fashion of building stone monuments, dolmens. menhirs, cromlechs, rock-cut tombs, &c., began to spread amongst the kindred peoples, not only on the west but also on the east of Egypt.

The evidence afforded by the excavations of Orsi and others in Sicily and Southern Italy seems to indicate beyond any doubt that Egypt was the source of the new burial customs that came into vogue in the Æneolithic Period. The features that seem so hopelessly inexplicable to the Italian archæologists are precisely those which the Egyptian evidence elucidates.

The absence of megaliths and kindred monuments in the track of the main Armenoid stream of immigration from Asia Minor into Europe is valuable negative evidence. The Armenoids of Asia Minor acquired a knowledge of copper weapons by contact with the Egyptians on the battlefields of Northern Syria; but they knew nothing (at the remote date we are considering) of stone-working or of megalithic monuments because they had no personal knowledge of Egypt.

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[1] Published in book form: *The Ancient Egyptians*, Harper's 'Library of Living Thought,' London, 1911.

[2] *Brit. Assoc. Reports*, 1910, p. 727.

5. *Excavations at Memphis and Hawara in* 1911.
By Professor W. M. FLINDERS PETRIE, *F.R.S.*

The sites excavated this year lay between Memphis and Hawara, about fifty miles south of Cairo. They are of various ages from prehistoric to Roman times.

At Hawara, where excavations had been made in 1888, about seventy portraits were found; many were entirely rotted, but nearly half were in tolerable condition, and some were as fine as any yet known. The most interesting is that of 'Hermione Grammatike,' the earliest woman professor of the classics that we know. Another is of an old lady named Demetris, aged eighty-nine. The manner in which the cedar panels of the portraits have been roughly cut down to fit the mummy suggests that they were not painted originally for funerary purposes; they rather seem to have been painted from life, in early or middle age, as pictures for hanging in the houses, and then to have been later cut down by the embalmer.

On the site of the Labyrinth a colossal shrine of red granite was found with two figures of King Amenemhat III Near this was half of a second shrine, and fragments of a third.

Of the statues of the gods there remained some busts and half-length figures, of Sebek, Hathor, and an unknown goddess with palm branches. Such figures of the XIIth dynasty are new to us, as (after the prehistoric age) no statues of gods are known till a few of the XIXth dynasty. They are finely cut in very hard white limestone. The latest date connected with the Labyrinth is given by an inscription on granite on a great architrave recording a dedication by a Ptolemy and Cleopatra, which must be at least as late as 200 B.C. This gives a range of over three thousand years for the existence of the great temple.

Other important sites of the XIIth dynasty, with extensive stone-work and building, are the pyramids of Mazghuneh, which were hitherto unknown. They were brick pyramids with passages of stone, on the same plan as those of Hawara and with external temples. It seems probable that they were built by Amenemhat IV. and Sebek-neferu. One pyramid has around it a wavy wall of brickwork, like that by the tomb of Senusert III. at Abydos.

Of earlier date is a prehistoric cemetery at Gerzeh, about four miles north of Meydum, dating from the middle of the second prehistoric period. Many finely formed stone vases of the usual types were found, also some beautifully flaked flint knives, and much pottery. The objects that were new were a slate palette, with a horned object, perhaps a Hathor-head, bearing stars on the points; a pottery horn ending in an animal's head; and some iron beads. This is the earliest occurrence of iron yet known, and it was probably derived from a piece of native iron from basalt.

In cemeteries of the XIIth and XVIIIth dynasties, and of the Roman age, were found some fine canopic jars, white limestone ushabtis, and a model couch of wood belonging to the earlier period. Of the Roman age are groups of toys, including a convex and a concave mirror, painted pottery figures of Horus in different attitudes, a stone sundial with the elongation of the pole star marked on it, several funerary inscriptions, one of which is dated under Claudius, and a variety of glass and pottery.

At Memphis in two fields in the temenos of Ptah the hinder part of a colossal sphinx was found, but as the ground ran into another property it has not yet been cleared. No building appeared in these areas, but to the south the foundations of a Christian church were found, composed of blocks from the temple of Ptah, with scenes and cartouches of Rameses II., some of which are unusual. Two deeply cut carvings—a capital and a border—belonged to the church, apparently dating from early in the sixth century.

6. *Predynastic Iron Beads from Egypt.*[1] *By* G. A. WAINWRIGHT.

This spring I found in unplundered Predynastic graves at El Gerzeh, about forty miles south of Cairo, two lots of iron beads, seven in grave 67 and two in

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[1] Published in full, *Man*, 1911, No. 100.

grave 133. Professor W. Gowland, F.S.A., has examined them, and reports them to be iron rust originating from wrought iron.

The possible sources whence the iron might have come are three:—

1. Reduction by the Predynastic people from ore.
2. Trade from the Negroes or others.
3. A find of native iron.

Sources 1 and 2 are improbable, nor is there need to trouble about them, as native telluric iron occurs in at least a dozen places in the world. It is especially liable to occur in basalt; and as Sinai is largely composed of this rock, and as in all probability the Predynastic people were accustomed to mine there, it seems that a find in Sinai of native iron of telluric origin is the most probable source whence it was obtained.

7. *Pleistocene Man in Jersey.*[1] *By* R. R. MARETT, *M.A.*

1. A cave named *La Cotte de St. Brelade*, on the south coast of Jersey, has yielded (*a*) osteological remains, identified by Drs. Smith Woodward and Andrews as those of a pleistocene fauna, woolly rhinoceros, reindeer, two kinds of horse, bovines, and deer; (*b*) thirteen human teeth, which Dr. Keith regards as those of an adult individual of the Neanderthal type, and indeed as being in certain features more primitive than any hitherto known; (*c*) numerous implements of well-marked Mousterian facies, amongst which none are of the *coup de poing* type with secondary chipping on both faces. These finds were all close together amongst the remains of a hearth not far from the cave entrance, under about twenty feet of accumulations, consisting of clay and rock-rubbish. Various interesting problems arise in regard to the geological cause of these accumulations, the source of the flint that served to make the implements, the connection of Jersey with the continent implied by the fauna, and so on. The cave is at this present moment undergoing further excavation, and much remains to be done.

2. A cave named *La Cotte de St. Ouen*, on the north coast, near the N.W. corner, has yielded implements of a Mousterian facies, but of a coarser workmanship, one of these being a heart-shaped *coup de poing*, whilst three others approximate to the same form. It is suggested that this cave belongs to an older Mousterian horizon than the other. Two separate hearths have been found here, the site having been recently searched completely. The stratification of the floor, which is about four feet deep, raises some important points.

3. Other evidence concerning pleistocene man in Jersey is scarce and uncertain: (*a*) Sporadic flint implements have been assigned to the Mousterian and other palæolithic horizons; (*b*) a human skull, and elsewhere the bone of a horse, have been found deep in the loess of the low-lying parts of the island, which in some cases underlies a stratum containing remains of the Early Neolithic period; (*c*) the raised beaches of Jersey and the neighbourhood provide a problematic scale of emergences and submergences, into which may be fitted the particular emergence coinciding with the Mousterian occupation.

8. *Cranium of the Crô-Magnon Type found by Mr. W. M. Newton in a Gravel Terrace near Dartford.* *By* A. KEITH, *M.D.*

Although the Crô-Magnon race was widely distributed in France towards the end of the Glacial Period, no remains of this race have yet been found in England at a correspondingly early date. From the fauna which accompanied the Crô-Magnon race one infers that its period corresponds to the excavation of the Thames Valley below the level of the sixty-foot terrace. For several years Mr. W. M. Newton worked a pit in the gravel terrace on the west side of the valley of the Darenth, a mile above Dartford, in the hope of finding palæolithic flints—in which search he was successful. The gravel excavated forms a stratum

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[1] Published with full details in *Archæologia*, vol. lxii. (1911).

eighteen feet in thickness over the chalk. The level of the terrace is eighty-three feet O.D., and may be regarded as contemporary with the sixty-foot terrace of the Thames Valley. The cranium described was found during excavations in this pit in 1902. It was not seen *in situ* but was found in a fall which had taken place from the face of the pit, after the workmen had left for the night. Mr. Newton examined this face of the pit both before and after the fall, and there was no evidence that the stratification had been broken as by a burial. The skull was believed to have been embedded in a 'pot-hole' which was situated about nine feet from the surface. Unfortunately the geological evidence as to the antiquity of the cranium is altogether incomplete.

Nevertheless Mr. Newton's discovery is of the kind which ought to be placed on record. The condition of the skull is not what is expected in a specimen of great antiquity; the bones are well preserved, not mineralised, and yet it bears evidence of having been embedded in the gravel over a great length of time. A small perforation on one side has admitted the moisture of the soil, which has worn in the interior of the cranial cavity a rut over 2 mm. deep. The cranium is of the Crô-Magnon type; its length is 207 mm.; its breadth. 150 mm.; its height, 116 mm.; its capacity, 1,750 mm. Unfortunately the face has perished so that we cannot rely on the further confirmatory evidence of the characteristic orbits and maxillae. Although the evidence is merely presumptive, still Mr. Newton's discovery is of the nature that deserves to be brought to the notice of archæologists in the hope that further research will supply us with facts which will definitely settle whether or not the Crô-Magnon race reached England in the Palæolithic period.

9. *Remains of a Second Skeleton from the 100-foot Terrace at Galley Hill.*
By A. KEITH, *M.D.*

In March of the present year Mr. W. H. Steadman, Headmaster of the Northfleet Council School, brought the remains of a human skeleton to the Museum of the College of Surgeons for examination. The bones came into Mr. Steadman's possession in either 1883 or 1884, when he was assistant to Mr. Mathew Heys at the Galley Hill School. It was found by the schoolboys in the face of the terrace gravel which was being worked at a distance of fifty yards from the spot where the skeleton of the Galley Hill man was found some four or five years later. To the best of Mr. Steadman's recollection the remains were found at a depth of about five feet. Mr. Mathew Heys, who was the first to see the famous skeleton *in situ*, corroborates Mr. Steadman's account.

The characters of the skull and bones give support to the probability of the bones found in 1883 or 1884 being those of palæolithic man of the Galley Hill type. The skull is long (199 mm.), narrow (140 mm.), and has many of the characters of the race. The calvaria is thinner than in the type specimen, varying from 6 to 7 mm., and, although giving a metallic resonance when struck, is not mineralised to the same extent as in the type specimen. The calvaria, although broken, is not distorted, and bears not only in its history but also in its features the same relationship to the type specimen as the second Brünn cranium bears to the first Brünn specimen. It answers very well to our conception of the female type of the Galley Hill race. It may be regarded as probably authentic and of the same age as the upper terrace of the Thames Valley, but before it can be accepted as such the confirmatory evidence of further discoveries is necessary.

10. *Fossil Bones of Man discovered by Colonel Willoughby Verner in a Limestone Cave near Ronda, in the South of Spain.* *By* A. KEITH, *M.D.*

During the winters 1909-10 and 1910-11 Colonel Willoughby Verner explored a large and unknown limestone cave at Ronda in the South of Spain. On the walls of the cave he found drawings, some of which are similar to the crude art of the caves in North Spain. In the superficial strata of the floor he found the remains of the pig and goat with parts of human thigh-bones, all coated with

a thick layer of stalagmite. Fragments of a primitive type of pottery were also found. In a deeper and presumably older part of the floor he discovered the fragmentary remains of a human skeleton of a peculiar type. The bones are mineralised and were embedded in stalagmite.

An examination of the parts show that they belonged to a man of about 1,480 mm. in height (4 feet 10 inches), of stout and muscular build. Although corresponding to the Bushman in stature, he differs from that race in many characters of his skeleton; in the points wherein he differs from the Bushmen he agrees with the early Neolithic European races, but he possesses certain peculiar features which distinguish him from both of these and from all modern races. Beyond the mineralised condition of the bones, their peculiar features, and the remains of an apparently extinct form of ibex found with them, there are no means of estimating the degree of antiquity of this peculiar Ronda type of man. Nothing is known of the physical characters of the artists of the Spanish caves. It is possible that the man discovered by Colonel Verner may prove to belong to the artist race.

WEDNESDAY, SEPTEMBER 6.

The following Papers and Reports were read :—

1. *Memorials of Prehistoric Man in Hampshire.*
By W. DALE, *F.S.A., F.G.S.*

The memorials of prehistoric man in Hampshire are connected, firstly, with the great beds of gravel which occur by the sides of its rivers and principally near their mouths. The gravel beds of the Avon from Milford Hill in Wiltshire down to Christchurch in Hants, and the cliff sections at Barton and Milford, at Hillhead, not far from Portsmouth, and at a point in the Isle of Wight nearly opposite, have all yielded palæolithic implements in great variety. No district is, however, more prolific than the valleys of the Itchen and the Test. In the gravel pits of the Southampton delta, which is covered with deposits from the rivers, we can see a mass of material from fourteen to twenty feet thick resting upon Bagshot or Bracklesham beds of Eocene age. The material is nearly all sub-angular flints, with here and there a piece of sarsen or a hardened mass of Bracklesham fossils.

The great age claimed for these gravel beds and for the associated implements is confirmed by the existence near Southampton of several streams which have cut for themselves secondary valleys of great depth right through the gravel since it was deposited and through the underlying beds. One of these valleys, at right angles to the Itchen near St. Denys, attains a depth of about fifty feet. When the Roman station of Clausentum was placed on a bend of the Itchen at the bottom of the valley the physical conditions of the neighbourhood were the same as they are to-day.

The implements gathered from these gravels are of great variety and are representative of all the various forms into which palæoliths can be classed. At the same time it is not possible to pick out certain forms and allocate them to distinct horizons as is now done by many on the Continent. There are also many rough and intermediate forms which would be called Eoliths by some.

Passing to the Neolithic period, Hampshire gives no evidence of any intermediate stages or anything to bridge over the great physical and palæontological gap which separates the two periods. As might be expected in a country where flint is abundant, Neolithic implements are plentiful, and specimens of almost all the types known elsewhere in Britain have been found. The most common implement, apart from the simple flakke, is the roughly chipped celt. Celts, very finely chipped, and also those partly or wholly polished, are also found. True arrow-heads, either barbed or leaf-shaped, are not common. Along the coast several small celts of green stone have been found which look like imports from the Continent. Apart from the implements, undoubted relics of Neolithic man

are few in Hampshire. A few long barrows exist in remote parts. One destroyed on Stockbridge Down some years ago contained an unburnt burial in a crouched form. Most of the conspicuous hills are crowned by defensive earthworks, and some of these probably date from Neolithic times. One of the finest is Danebury, near Stockbridge. The inner, or principal, vallum rises thirty-two feet above the ditch, and there is an elaborate system of banks defending the openings. A better known earthwork is that on St. Catherine's Hill, Winchester, which may belong to the Bronze Age. Many of the sides of the downs have 'lynchets' or terraces of cultivation which are of uncertain age. The only megalithic monument in the county is on the western side of the Isle of Wight and is called the 'Longstone.' It was evidently originally a dolmen. One stone remains upright, and the companion stone lies by its side. Barrows of the Bronze Age are very abundant. This is particularly the case in the New Forest, where one may look over vast tracts of country unaltered since prehistoric times, save for the existence of the Scotch fir. Many hoards of bronze implements have been found in the county, and single specimens are not scarce. Some of these are of an early type. One is an early dagger of the type from which the spear-head was evolved. A very early flat celt, belonging to Period 2 of Professor Montelius, was also found near Southampton. This is of a type now commonly found in Ireland. A short square-socketed celt and a lance-head with loops, cruciform in section, both also have Irish affinities, and may be regarded as relics of that time in the Bronze Age when there was commerce between Ireland and Scandinavia, and Southampton was a convenient port of call.

2. *The Bearing of the Heraldry of the Indians of the North-West Coast of America upon their Social Organisation. By* C. M. BARBEAU, *B.Sc.*

This paper attempted to describe in brief (1) the typical kinds of social grouping found amongst these tribes; (2) the right claimed by these social units to the exclusive use of distinctive crests, emblems, or armorial bearings handed down from generation to generation; (3) the peculiar devices employed by the privileged owners of these emblems and of the names therewith connected in order to bring about the normal working of a well-established and consistent system of social organisation, based upon the requirements of a semi-nomadic mode of life.

The most important type of social unit found amongst the Northern tribes, namely, the Tlingit, Haida, Tsimshian, Heiltsuq, and Northern Kwakiutl, is the phratry. Its influence pervades all matters of domestic and political life. Thus the potlatch and similar transactions of economic concern, involving exchange of property, loans with interest, &c., can only be entered upon with members of the other phratry. Again, in events of social and domestic interest, such as birth, initiation, marriage, the erection of a house, and burial, the assistance of the allied phratry must be solicited and paid for. Finally, most notable circumstance of all, one may never marry within one's own phratry. Other types of social unit are the clan, the family, and the house group, each of which can claim distinct crests for their exclusive use. Amongst all these tribes, with the exception of the Kwakiutl, the right of membership is inherited in the matrilinear line. Amongst the latter, however, the system is far more complicated. Certain rights devolve through the father, others through the mother. Moreover, the use of certain crests may be secured through the slaying of their legitimate owners in war. Another interesting feature in the social morphology of this people is the fact that two different ways of grouping themselves prevail severally in summer-time and during the winter ceremonials. In summer they are arranged into clans, but for the winter are organised quite differently into two large fraternities (secret societies). These fraternities may not only be inherited from parents but secured by payment or otherwise. They are concerned with ritual dances, dramatic performances, potlatches, and so on.

3. *The Early Bronze Age in Britain.* *By* O. G. S. Crawford.

The development of the study of prehistoric archæology in this country may be divided into four periods: (i) The 'Brut' period, eleventh to fifteenth centuries A.D.; (ii) the 'Ancient Briton' period, fifteenth century to 1860; (iii) the Evolution period, 1860 to 1900; and (iv) the Distribution period, 1900 to to-day. During the Evolution period, prehistoric science in this country was crowded out by the growth of other branches of study, some of which greatly confused the issues. Hence the coming of the Distribution period has been delayed. The evolution of types must be known before their distribution can be mapped.

The paper dealt with the subject in the following manner: Firstly, the place of the Bronze Age in the evolution of the culture in Britain, together with the character and extent of neolithic culture, so far as known at present, was discussed. The distribution of flat celts and beakers was explained with the aid of maps, the following four main areas of habitation being indicated: (i) East coast of Scotland and of Northern England; (ii) the Peak District; (iii) the Margin of Fenland; and (iv) Salisbury Plain.

Geologically, emphasis was laid upon the great extent of forests over English clay lands, the regions settled by the Early Bronze Age invaders being those where there was no forest. There are generally limestone regions where the soil is shallow and light, as, for example, the Peak district, the Fen margin, and Salisbury Plain. In such regions the bulk of the aboriginal neolithic population was probably settled. The effect of climate is most marked in the relatively dry, warm lowlands of East Scotland.

Lastly, the author discussed the source of the metals used in the Early Bronze Age. The geological absence of the requisite metals in certain thickly inhabited regions proves the existence of an extensive trade. This is confirmed by the abundance of moulds for flat celts found in Aberdeenshire. The following problems concerned with this subject were then discussed: The Irish gold trade and the gold of Wicklow; the probable course of trade routes as indicated by the nature of the country and confirmed by isolated discoveries of flat celts; the nature of the trade.

4. *Report on the Lake Villages in the Neighbourhood of Glastonbury.*
See Reports, p. 134.

5. *Notes on Human Remains of Ancient Date found at Weston-super-Mare.*
By H. N. Davies, *F.G.S.*

The remains were found at a depth of eight feet on the ancient shore line of a bay, now a quarter of a mile inland. They were in a position of rest; one leg being slightly drawn up, and the head resting on the right hand. No traces of clothing, weapons, or implements were found. The interment had evidently taken place in the course of a ferruginous stream or near chalybeate springs, as the sand grains were cemented together by oxide of iron, the bones were stained a dark chocolate tint and were heavy, while the softer parts of the long bones were replaced by a ferruginous deposit of sand and iron oxide. The brain-case of the skull, which is in splendid preservation, was filled with ferruginous sand, the eyeballs being replaced by globular masses of hematite, the soft parts of the nose also being replaced by the same material. The lower jaw is cemented to the upper by an iron cement, which also holds many of the teeth in position. The alveolar ridges show considerable absorption, and there are traces of disease in the fangs of some of the teeth.

The supraciliary ridge of the skull is prominent, and the occipital region protuberant. The transverse arch is well rounded, and the antero-posterior curve slightly depressed in the frontal region, and flattened in the post-parietal region, and regular in the parietal region. The orbits are broadly elliptical. The lower jaw is very square, and the chin broad and sharply pointed at the angles.

Among the measurements obtained were: *Skull*—Max. antero-posterior

length, 198·4 mm.; Max. transverse breadth, 147·6 mm.; Bizygomatic breadth, 138·1 mm.; orbital height, 44·4 mm.; orbital breadth, 35·0 mm. *Femur*—Max. length, 182·6 mm. The calculations for stature give 1778·0 mm. (Beddoe) or 1719·0 (Manouvrier). *Indices*—Cephalic, 74·40; facial, 117·57; orbital, 78·60. Although the gnathic index is not exactly ascertainable, the skull is certainly orthognathous.

Finds of prehistoric interments are frequent on the southern slope of Worlebury, which is the site of an extensive prehistoric settlement. All the skulls from the site are dolichocephalic with indices ranging from 72·0 to 74·0, but they have weak pointed lower jaws, slight superorbital prominences and squarish orbits. They belong to the Iberian types, differing markedly from the present specimen. Though it is impossible to state the age of this interment, it may be that of a later prehistoric immigrant, or of Roman, Saxon, or Dane. It is not improbable that the skull may be that of a Roman legionary who fell in the great attack made on the stronghold in the first century A.D.

6. *Later Finds of Horse and other Prehistoric Mammalian Remains at Bishop's Stortford, with further Anatomical Notes on the Fossil Skeleton described at the Sheffield Meeting* (1910). *By* A. Irving, *D.Sc.*, *B.A.*

In *Nature* for June 8, 1911 (p. 491) there appeared a short note announcing the first instalment of these later 'finds'; chiefly bones of *Equus caballus* and of *Bos longifrons*, found (in the excavation of a gas-pit) associated together upon the glacial sands and gravels with which the deep pre-quaternary channel in the chalk has been filled,[1] under six feet of peat (formed *in situ*), and brown clay. The evidence seems to point to the late Neolithic or Bronze Age for the new 'finds.'

Along with three well-preserved lower jaws of *B. longifrons* two broken shoulder-blades of *Equus caballus* and the three most important limb-bones have been recovered. These limb bones are of precisely the same type of horse as the skeleton unearthed in the pond-excavation.[2] Exact measurements give the following results obtained by dividing the central length in each case by the least breadth of the bone:—

	Radius	Metacarpal	Metatarsal
For the skeleton . . .	8·64	6·47	8·10
For the new finds . . .	8·67	6·43	8·50

The new 'finds' must have belonged to a horse which (by Professor J. C. Ewart's formula)[3] stood thirteen hands at the withers, as against the fourteen hands of the skeleton.

In the structural details the two forearms agree remarkably, and differ from those of the polo and other modern pony varieties with which they have been compared.[4]

Two other horse-bones were found last year on the east side of the valley, under twelve feet of the post-glacial 'rubble-drift,' both tallying in size and otherwise with the corresponding bones of the skeleton found on the western side of the valley. There occurred near by a fine boulder (glacially striated) of carboniferous limestone, weighing nearly two cwt., eight feet below the natural surface. It measures 23 inches by 17 inches by 10 inches.

July 1911.—Further down the valley a deep trench (7 feet to 12 feet) has been dug to lay down a new main sewer. The bottom of the trench for nearly a furlong exposed the glacial shingle which was found beneath the peat in the four trial-borings for the gas-pit (*supra*), passing up into coarse, flinty 'Schotter' of the valley flank. In places the peaty silt of the gas-pit excavation recurs.

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[1] A. Irving: *P.G.A.*, vol. xv., February 1898 (pp. 224-237).

[2] A. Irving: 'The Prehistoric Horse of Bishop's Stortford': *Brit. Assoc. Reports*, Sheffield, 1910 (p. 736).

[3] J. C. Ewart, F.R.S.: 'Restoration of an Ancient Race of British Horses,' *Proc. R. Soc. Edin.*, 1909–10 (p. 297).

[4] *Cf.* Nehring: *Fossile Pferde, &c.* (pp. 126, 127).

Under 2½ feet of this in one place was found (7 feet below the road) a peat-stained radius of horse tallying exactly with that from pit-excavation, strongly stained with iron phosphate, also a third metacarpal index 6·5. In this glacial shingle Pleistocene mammalian remains occur. These [as identified at the Brit. Mus. (Nat. His.)] are *Elephas antiquus* (tooth), *Hippopotamus* (tooth), *Bos primigenius* (tooth, ramus, metatarsal), *Cervus megaceros* (?) (fragments). Worked flints were also found.

Attention is drawn to the identity in size and proportions of the skull of the Stortford Horse and to the Grimaldi Horse described by M. Marcellin Boule, to the Starnberger Horse figured by Naumann; also the limb-bones with those from Spandau figured by Nehring (*op. cit*).

Measurements on the flat give for the frontal index:—

Skull of the Stortford Horse	59·1
Skull of the Grimaldi Horse	59·1
Skull of the Starnberger Horse	59·8

Tracings made of the enamel of the grinding surfaces of *p.m.* 4, *m.* 1, and *m.* 2 of the Grimaldi Horse apply in every detail to the Stortford specimen.

7. *Report on the Excavation of a Prehistoric Site at Bishop's Stortford.*

See Reports, p. 131.

8. *A Roman Fortified Post on the Nottinghamshire Fosseway: A Preliminary Note on the Excavations of* 1910 *and* 1911. *By* T. Davies Pryce.

Excavations have recently demonstrated the existence on the Nottinghamshire Fosseway of a post, situated midway between Ratae and Lindum, which has been identified with the Margidunum of the second and third Antonine Itineraries. The remains are approximately trapezoidal in shape, the east and west sides being parallel, with an internal area of six acres and a measurement over all of twelve acres. The Fosseway passes through from S.W. to N.E. over and through the southern ditch and rampart of the original earthwork.

Excavations of 1910 *and* 1911.

(*a*) *Trenches near the Southern Rampart.*—Roofing, coloured wall-plaster and isolated *tesseræ* were found, but no foundations of houses. Superimposed pavements furnished evidence of three occupations.

(*b*) *Section through Southern Rampart.*—Rubble work on a foundation of undressed stone packed in clay was found. The greatest height of the rubble above the undressed stone was 3½ feet and its basal width 10 feet. No outer or inner stone facing was found.

(*c*) *Section through the Southern Fosse.*—The broad Southern Fosse was found to be composed of three ditches, angular in form, separated by two clay platforms. The distance from the centre of the inner to the centre of the middle ditch was 30 feet; from the centre of the middle to the centre of the outer ditch was 34 feet 6 inches. The counterscarp consisted of a thick layer of thrown up clay.

Finds.

(1) *Pottery.*—(*a*) Rude fabric made of clay mixed with pounded shells and ornamented with primitive incised markings, found below the layer of typical Romano-British discovery and almost certainly Pre-Roman and Celtic. (*b*) Samian Ware or Terra Sigillata. Many examples of first century fabric as Form 29 with winding scroll decoration, a beautiful fragment of the plain dish Form 18, and a fragment of the rare and early Form 15. The second and probably the early part of the third centuries were represented by numerous examples of Form 37, with the usual styles of decoration. Plain forms referable to the second century were also abundant. (*c*) Romano-British and other ware.—Fragments of amphoræ and mortaria were numerous, also much dark and grey

local (?) ware. Examples of Upchurch, Castor, and New Forest fabric were also discovered. Some fine fragmentary specimens of indented ware, with incised markings, from Eastern Gaul, are amongst the collection. They have a bronze or metallic appearance.

(2) *Iron Objects.*—Two short swords of Roman type, keys, nails, &c.

(3) *Bronze and other Ornaments.*—A fibula of antique pattern found at a depth of five feet. A gilt copper pendant for a horse trapping, having the shape of an amazon's shield with a rude representation of a horse upon it. The lateral points were cut into the form of eagles' heads. Probably of fourth century date.

(4) *Bones.*—Skeleton of an old man at depth of four feet; bones of three infants at three feet. Animal bones were numerous. Those of *Bos longifrons* extended down to the lowest levels, whilst the horse was not represented at a greater depth than two feet. Other remains represented sheep, pigs, dogs, the legbones of fighting cocks showing the spurs, and ducks. Tusks of wild boars, sawn antlers of red deer, and the bones of the goat were also found. Shells of mussels, whelks, edible snails, and oysters were abundant.

(5) *Definitely Pre-Roman objects.*—A ground axehead or celt of green chloritic slate; depth 4½ feet, and two bronze socketed celts 3½ inches in length.

(6) *Coins.*—Victorinus (265-267), Carausius (287-293), Constans (333-350), Eugenius (392-395).

SECTION I.—PHYSIOLOGY.

PRESIDENT OF THE SECTION.—PROFESSOR J. S. MACDONALD, B.A.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

THE special difficulties of physiology are well known to a large section of my audience, but it may be permissible to illustrate them by reference to an individual case. Take for example those small capsules which are found in the kidneys at the very summit, so to speak, of the problem of renal secretion. These small bodies each occupy a space of less than two thousandths of a cubic millimetre. Within their interior they contain several different kinds of blood-vessels that represent the structures of greatest mechanical interest when dealing with the circulatory system, omitting of course the heart. This almost complete sample of the circulatory mechanism, itself formed of a congeries of parts and unitary mechanisms, is enclosed by two or three thousand cells of specific glandular function. Every one of these cells again is a complex of mechanisms about which we cannot rightly think until we reduce our conceptions to the level of molecular dimensions. Enclosed then in this minute space, within a mass that weighs two thousandths of a milligramme, lie quite a series of the problems in which physiology is interested.

The difficulties occasioned by this minuteness of parts, and by the manner in which they are complexly mixed together, render direct investigation of single problems possible only in the very simplest cases, as, for instance, the red blood corpuscle and the nerve-fibre.

A consideration of the dynamic properties of the red blood corpuscle is perhaps the simplest task in physiology. By the aid of the centrifuge these bodies can be obtained free from the embarrassing presence of other cells, may even be washed and immersed in definite solutions of known value. In addition, these compressed discs, the study of the forces normally compressing them open to research by variations in the quality of the surrounding solutions, contain no nuclear reactions and but the one material of primary dynamic importance.

Everyone knows, however, that even in this case the dynamic conditions are being investigated largely in an indirect fashion. The material of primary importance, hæmoglobin, is stable except with regard to the one well-defined reaction with oxygen to which it owes its utility. This material may readily be obtained pure and its properties examined in homogeneous solutions, and these properties may again be studied after adding to this solution such secondary substances, lipoids and inorganic salts, as are also present in the red blood corpuscle. In the hands of members of this Section such studies are not only increasing our knowledge of the properties of hæmoglobin, but are also rapidly leading to a knowledge of those very dynamic conditions with which it is surrounded when present within its microscopical site in the red blood corpuscle. In this very simple instance, the parts of the mechanism being known, it is possible to arrange them in such a fashion as to limit our conceptions of the way in which they are actually arranged within the body.

In cases of greater complexity, where no doubt in course of time the same method of indirect attack will be adopted, in preparation for this event, the necessities of the moment largely confine our attention to a discovery of the various parts present in these mechanisms. In fact, the first requirement is a knowledge of the micro-chemistry of those more complex structures, that is to say, a precise knowledge of the chemical materials distributed in minute spaces of microscopical dimensions. It is well known that my predecessor in this honourable post, Professor Macallum, of Toronto, has contributed largely to our knowledge of these matters, and that he further assisted us to a right conception of the forces in action between these minute masses of material by his excellent Presidential Address to this Section.

Thinking of the body as no more than a collection of chemical reactions, this elaborate separation of parts in a multiplicity of extremely small spaces protects the individuality of a certain large number of reactions, whilst at the same time securing a rich maintenance of contact with supplies of raw material and a ready means for separating the end-products of reactions from the materials in reaction at each point. Every nucleus, surrounded by its constellation of secondary chemical reactions, is thus given certain limits of size, surface, territory, and environment. These are physical necessities of arrangement possible within the conditions of solution met with in the body, and no doubt largely due to physical states developed by each reaction—that is to say, that the products of each reaction exert a physical influence and produce characteristic physical arrangements. It is not without interest to realise that cell-growth, and the increase in nuclear surface with which it is attended in cell-division, is apparently initiated at every centre by what is doubtless a physical process, and what, as Loeb has shown us, may be accelerated by definite physical change. Such effects of growth are best studied in those early days of enormous expansion when the ovum increases to one thousand million times its original weight, and it is at this time that these separative physical consequences of chemical reactions are most apparent.

During this primary expansion not only have the reactions of nuclear matter been extended to occupy some hundred million times more mass, but it is also true that they have been modified in a very large number of ways, and doubtless this as the consequence of special conditions, extrinsic conditions, existing at the time of formation of each separate part. These modifications are largely shown by differences in appearance and structure, and are each attended by some difference in the function of typical groups of cells. A singular persistence in the similarity of structure and function exhibited by successive generations of similarly placed cells is no doubt sometimes due to the maintenance of those special extrinsic conditions which occasioned their initial modification. In these cases reversion to an original type may occur on immersion in formerly pre-existent conditions, and indeed a whole series of different structures make their appearance as the conditions are further variously modified, as is sometimes seen in the regeneration of parts.

There is, however, seen in some cases a greater degree of persistence, studied for example in malignant growths, which is largely retained even when the extrinsic conditions are greatly modified; and in such cases there has doubtless occurred some elimination and refinement—that is to say, rather an abstraction than an addition of character—as the consequence of the initial modification.

In certain places in the adult, physical conditions due to the modification and acceleration of chemical reactions are still frequently provocative of nuclear growth and subdivision: thus in the tonsils, follicles, patches, and lymphatic structures generally that are embedded in the surface of the alimentary canal. These structures, characterised by their great wealth of nuclear material, experience great nuclear change, to which they are largely stimulated by chemical substances derived from foreign organisms. Specifically affected by each chemical substance, they are probably the site of manufacture of specific neutralising substances that are driven from these sites of activity into the portal system almost as soon as the substances exciting their appearance are driven in from the absorbent surface of the alimentary canal.

In other places in the adult, however, such conditions never recur after a certain date in development. In these places the nuclear material has been so refined as to be irresponsive to conditions that accelerate and modify the

reactions of nuclear material in other parts. Permanent sites of monotonous nuclear activity are formed and maintained in such places until the moment when some unusually extreme condition still further limits their activity and terminates their existence. It is significant, too, that this may happen when the condition is not sufficiently extreme similarly to cut short the reactions of other parts.

Now the latter case is typically illustrated by reference to the nervous system, which is thus seen as the site of a severely limited quality of chemical activity. That it is also restricted in amount may be further emphasised by reference to the relatively minute quantity of nuclear material which is present in this system. Thus it is probable that if a direct comparison between the cells of the nervous system and the lymphoid cells to which I have alluded were possible, the essential difference found would be a difference between the stability of certain chemical material in the one case, and a frequently modified wealth of chemical reaction in the other; so that of the two, the nervous system would be the more comparable with the red blood corpuscle.

Thus, if when reviewing the wide array of function in which the nervous system participates, we are led to foresee for each of its cells a great variety of chemical change, or, if when surveying the great differences in function of the organs of the body we are led to expect typical chemical differences between those several parts of the central nervous system with which they are individually associated, we are arrested by this clear evidence of a universally distributed monotony of simple chemical state.

It is true that certain drugs affect some groups of cells within this system more readily than others. None of these instances are, however, of such a kind as to demand the inference that there was any essential difference between different groups of cells. In most cases, indeed, it is probable that differences in relative quantity, and in such simple factors as relative state of solution, are responsible for these effects. Thus there is nothing to refute the statement that all the cells of the nervous system contain chemical materials of an exactly similar kind. Just as every liver-cell is like every other liver-cell in their general chemical character, so in the nervous system are all the cells chemically alike.

Glancing from the liver-cell to the nerve-cell, however, there is at once seen a marked difference of a kind we have not yet considered. The chemical experiences of the liver-cell are multifold, but in the main alike for each cell, and it is thus not surprising that the chemical reactions are in the main the same in every cell, no matter how multifold they may be. The physical experiences of the liver-cells are similarly the same for each cell, and we are not surprised that in physical appearance there is as monotonous a similarity between all the cells in the liver as there is monotonous chemical similarity between all the cells in the nervous system. In the nervous system, however, there is no monotony in the physical character of the cells. It is a notable physical fact that the cells of the nervous system have diverse shapes and sizes, and still more so that these are such as to bring them into a kind of physical relationship observed in no other epithelial organ. It is a notable physical fact that cells originally separated by considerable distances are brought into close contact by a growth of processes, and that they are in this way arranged into chains forming definite paths for the transmission of physical influence through this system.

Before attempting to explain the manner in which physical conditions give rise to this arrangement, I must briefly sketch the differences in physical state which may be met with in these cells. Thus there are the states of excitation, of rest, and of inhibition. I may simplify matters by saying that there are reasons for considering excitation as associated with an increase in pressure, either due to a temporary increase of particles in motion within the solutions of the cell or to some acceleration in the motion of particles initially present. In rest these particles are in their normal quantity and have their normal motion. During inhibition the particles are decreased in number, or have a retarded motion. Associating excitation with an increase, inhibition with a diminution, and rest with normal degrees of molecular activity, we shall not be far away from the facts.

Everyone is aware that increased molecular activity is associated with a

tendency to break bounds, or when taking place behind resistant but distensible bounds with a tendency to expand the region of activity. Thus it happens that the excited cell tends to grow in size, whereas, on the other hand, the inhibited cell tends to diminish, and the resting cell to remain unaltered. These several proceedings are possible so long as the surface membranes of the cells, or of structures within them, which form bounds resistant to the pressure of molecular activity, are at the same time porous to water molecules; and this we know is within limits true—namely, that the cell is enclosed by such semi-permeable membranes. Thus when the excited nerve-cell grows in size, and the region of molecular activity is thus increased, the materials within the cell are diluted by an admission of water.

Attention is now directed to the probability that there is some kind of material in solution within the cell which takes no part in this increase of molecular activity; is, on the other hand, retarded in its motion by agglutination into colloidal clusters, and may finally be precipitated. I, for my part, have no hesitation in saying that there is every probability that this is indeed the primary phenomenon of excitation, this precipitation. Leaving that point, however, alone, it is probable that this tendency towards precipitation occurs. This material, precipitated and diluted, thus loses some of that mass-action formerly holding in check its formation by the particular chemical reaction that is always tending to produce still more of it. More of this material is thus produced within the excited cell, and is in turn precipitated, and still more and more. We may therefore think of these excited cells as laying down a structure which I will ask your permission to describe as a cuticle. The nerve-fibre is the cuticle of the nerve-cell. Once give it such a name, as is in part justifiable, and no one will be surprised that these structures are pushed out to an extraordinary distance from their parent cells, and that their length is measured not like other details of cell-structure in thousandths of millimetres, but sometimes in metres, and therefore on a scale with units one million times larger than usual.

If we entertain this idea, that nerve-fibre growth is proportional to excitation, we are prepared for the statement that the physical characters of the cells within the nervous system and their relations to one another are all due to their relative experience of incidents of excitation. We face the fact that their chemical work is of a universally monotonous type, a drearily slow and respectable type, and that their physical features and arrangements are capable of very simple explanation.

Now structure is everywhere the outcome of function, and those functional developments that lead to the growth and differentiation of structure contain the most interesting and most fundamental problems of physiology. If it is thought that the main relationships of parts within the nervous system are fixed from an early date of development, it would then seem that to the physiologist the nervous system is a place of very limited interest. But this is by no means the case, the relationship of parts is by no means a fixture within the nervous system. In so far as it is fixed, it is the sign of the orderly action of circumstance upon the structures of the body, and the result rather than the cause of the monotony of existence. There is, however, no need to labour this point or to debate our interest in this system. One portion of the nervous system is the seat of the mind, a fact to which I will return later. The whole of it is the very essence of the unity of the organism containing it. It is the rapid transmission of physical states through its individual nerve-fibres, and the modifications in transmission determined by passage into its constituent cells, which serve to weld the actions of the several parts of the body into that phase of common action which is suited to the necessities of the moment.

That there is no moment during life when there are not many paths through the central nervous system engaged in this business of transmission is a statement of commonplace realised by all. There are not, however, in my opinion, a sufficiently large number of persons sufficiently impressed by that greater truth, discovered and analysed by Sherrington: that no path is thus busy without there being at the same time some other path maintained in a condition of enforced rest. Whenever the system is excited at one part it is also inhibited at another, and it is this phenomenon that lies at the root of the harmonious effects produced by this system, and forms the means whereby action suspends antagonistic action.

When considering the influence of states of excitation upon the growth and arrangement of structures within this system, it follows then that I cannot afford to omit some proper consideration of the manner in which this phenomenon of simultaneous inhibition may be explained, and of its influence on the growth and arrangements of structures. To get a clearer view of this process we must think in detail of the probable nature of the structures involved in the simplest case of transmission through the system. It is indeed a simple thing to form a picture of the track entering the system, the structure called the afferent neurone. Here we have a long length of cuticle, or nerve-fibre, stretching right from the surface where it is liable to stimulation by change in circumstance, or—more complicated case, but very usual one—by the maintenance of circumstance. This afferent neurone is mainly cuticle. It is true that its cell-body is placed like a hump somewhere on its back, but this is no more than an index that it is never inhibited. Thus from the site of change of circumstance right into the nervous system transmission is of the simplest kind, since all we know of this nerve-fibre is that it transmits most of the excitations it receives at a rapid pace and without loss from one end to the other. We can therefore see the excitation planted by it into every cell with which it comes in contact within the system. By some of its branches it plants this excitation into nerve-cells, whose nerve-fibres pass out to reach the site of action. It is a simple matter again to picture this first set of efferent neurones as receiving an excitation which they then transmit. That there is a certain complexity in the process is a fact with which we are not at present concerned.

But now, what about the site of antagonistic action, the parts that are held in a state of enforced rest? To them also lead perfectly similar efferent neurones, incapable of producing any other effect in the site of antagonistic action than that of exciting it or transmitting excitations towards it. We must therefore conclude that it is this second set of efferent neurones that are inhibited and maintained in a condition of enforced rest. How then does the change transmitted into the several branches of the afferent neurone, having the same character as it invades every branch, succeed in causing diametrically opposite conditions in two groups of perfectly similar efferent neurones? There is but one answer to this question, namely that transmission into the second group must be through some intermediate mechanism which reverses the character of the change. Now I have no hesitation in naming definite structures in the nervous system as being alone those to which we can impute this reversal, namely certain intermediate neurones which have a way of being interpolated between afferent and efferent neurones. Such neurones are seen in the cord sometimes sending their main nerve-fibre towards efferent neurones placed on the other side of the cord, and in the cerebellum the large cells of Purkinje are seen to be approached by afferent nerve-fibres in this double fashion; one set reaching them directly, the other set indirectly through intermediate neurones. We shall then picture neurones with short nerve-fibre processes as placed in these paths that are inhibited, and as sometimes responsible for this singular reversal of the transmitted excitation.

In this connection, too, we must deal briefly with another fact observed by Sherrington, that certain drugs, tetano-toxin and strychnine, affect these intermediate mechanisms in such a way that they lose their power of reversing the character of change transmitted through them. When these drugs are applied to any part of the nervous system action and antagonistic action are simultaneous consequences, and the stronger wins. Of the greatest interest, too, is the fact that this disturbance of the process of reversal may be obtained in a graduated manner by the application of such drugs in varied strengths of solution. It is thus clear that there is nothing peculiar about the nerve-fibre portion of these intermediate neurones, since when given excitations to transmit they transmit them, although it is so frequently their normal business to transmit inhibitions. Clear, too, that their cell-bodies frequently inhibited like those of the efferent neurones may also with a slight modification of condition tend towards excitation, or, as a matter of fact, be excited, again like the efferent neurones. There is no difference discoverable here between these two sets of cells other than a difference of degree. The one salient fact demanding explanation is this difference under normal conditions in which the efferent neurones are seen as

excited by identically the same character of transmitted change that inhibits the intermediate neurones.

Now it would be a simple matter to show that all these points might be dealt with adequately on the assumption that nerve-cells invariably contained a mixture of two materials, existing in different proportions in different cells, each of which was forced into a diametrically opposite physical state to the other as the result of changes in physical conditions of the kind transmitted by nerve-fibres.

It is of interest then that there is definite reason to suppose that within nerve-cells there are always two substances which seem to have their states diversely affected by different conditions. One of them is the characteristic constituent of what I have been irreverently terming the cuticle, the nerve-fibre; and the other a complex material which apparently represents the primary product of nuclear activity, and is spoken of as the material of Nissl. It may seem a weak point in my use of the term that this cuticle-stuff is found within the cell-body. Perhaps so, but perhaps also not so; the point is not worth discussing. The point really worth discussion is as to whether it is true that these substances are affected in diametrically opposite ways by the same change, just as if, for example, one of them was possessed of acid and the other of basic characters; so that the basic was precipitated, and the acid dissolved by the addition of an alkali: since if they exhibit any opposite behaviour in the presence of the transmitted excitation, then it is indeed probable that their admixture is responsible for many of the orderly vagaries of transmission through nerve-cells. I am proceeding as if this is really true to a consideration of its influence on the development of nerve cells.

Imagine a developing afferent neurone in contact with two other neurones, but by different extents of its surface, so that it transmits a larger quantity of change to the one than to the other. In both cases it affects an algebraical sum of opposing properties, and we might think of it as effecting a compression and an expansion. Now let there be the slightest difference in the force required to compress and to expand, and it might readily happen that the effect of a minimal dose might be to produce an algebraical sum in favour of compression, whilst a maximal created a general effect of expansion. One of these cells then might be habitually excited and grow a cuticle traversing considerable distances in the central nervous system; whereas the other is inhibited until the accumulation of charges previously received add up to the dose required to tip the algebraical sum in favour of excitation, and then first commences the growth of a short nerve-fibre.

This, however, involves the assumption that these cells of both classes store up all the transmitted energy they receive, that they do not leak, do not transmit, and thus grow their nerve-fibres from the effects of accumulation. Within certain limits this supposition is sound, since we are familiar with that summation which is a leading feature in nerve-cell conduction. Below a certain definite quantity of charge they do not leak, and are found by a second impulse arriving some little time after an apparently ineffectual predecessor in a new state, so that the new-comer is effectual. Now if no new-comer arrives in time we must suppose the energy due to the first as having affected the growth of the cell in one direction or another—that is to say, in one direction if it produced the change characteristic of excitation, and the other if producing to a minimal degree the change characteristic of inhibition. It is legitimate, too, to suppose these limits as set by the capacity and extent of excitable contacts, The larger the extent of contact the sooner and the more effectual must be the leakage. Thus we may readily picture the excited neurone as growing more and more cuticle until this growth is checked by the number, extent, and capacity of the excitable contacts made in course of growth. When a certain measure of growth has occurred we may suppose that residual charges below the margin of leakage are now only just sufficient to maintain the district of cuticle that has been laid down. We have therefore encountered the limits of growth of the nerve-fibre.

As for the second cell, which we have considered as mainly inhibited. In it the mass-action of the products of nuclear change is diminished and we must think of it as enlarging its cell-body by an increased nuclear activity; possessed

of a short cuticle but an extending cell-body, possessed of no more than a short nerve-fibre and an extensive set of dendritic processes. As each new dendritic process makes contact with a new branch of the excited afferent nerrone its growth will be more and more limited. We have here, then, encountered the limits of growth of the nerve-cell.

There is no difficulty other than that due to the short time at my disposal in compounding these statements so as to cover the whole scale of differential cell-growth, and within each cell of the relative growth of its several parts, that is observed within the nervous system. I may perhaps be permitted this abrupt closure to a development of the probabilities underlying the following expression of opinion.

I hold it as probable that all the individual structures of the nervous system, and so in the brain, have just so much difference from one another in size, in shape, and in function, as is the outcome of that measure of purely physical experience to which each one of them has been subjected; and that the physiological function of each one of them is of the simplest kind. The magnificent utility of the whole system, where the individual units have such simplicity, is due to the physically developed peculiarities of their arrangement in relation to one another, and to the receptive surfaces and motor-organs of the body.

To relieve the monotony of this discussion, let us turn away for a moment to the consideration of certain physical mechanisms found in the body, external to the central nervous system; mechanisms that are placed, so to speak, upon the front of that system so that they are capable rather of affecting it than of being affected by it, and this to such a degree that we must suppose them as rather assisting in the development of the central nervous system than as being assisted to their development by the central nervous system. There are, for example, the lens systems of the eyeball and the sound-conducting and resonant systems of the ear. Now, in dealing with the central nervous system, the suggestion was made that it was developed by just such physical conditions as are transmitted through it in its adult form. In dealing with the eyeball, it is clear that an admission of this sort is not easy. During the evolution associated with natural selection the eyeball is formed by light. It must be so. The eye is as perfect an optical instrument as could be made with a full knowledge of the part played by matter and special arrangements of matter in reflecting, refracting, and absorbing light. Long prior to the development of man, who at a later date acquired sufficient knowledge of these properties to aid him in the formation of crude lenses, there was to be found upon the general surface of the animal world lenses of very great perfection, in fact, complete cameras. Had the first optician then known what was in him he would have been saved infinite pains. Had he indeed known even the lens systems formed on the leaves of plants. Surely there is no escape from the statement that either external agency cognisant of light, or light itself, has formed and developed to such a state of perfection this purely optical mechanism, and that natural selection can have done no more than assist in this process. The influence of natural selection depends upon the frequency of variations, and it is important that there is no variation that has not behind it some cause. In this special case of variation in physical arrangements, it is indeed probable that the most frequent cause of variation would be exerted by physical conditions, since in this case the factors that are thus introduced by variation are not distinguished by any chemical peculiarity. Thinking of the few possible physical causes of variation, there can be little doubt that light itself would produce some variation in this optical instrument, and that the variations produced by light would be just those more likely to be adapted to the subsequent traverse of light than such as were accidentally produced by some other physical cause. Accepting such a statement, we may say that in the course of development light formed the eye by its action upon such tissues as those of which the general surface of the body is composed. Now in just the same way there can be little doubt but that sound formed the sound-conducting and resonant portions of the ear. We may perhaps go further than this statement, and say that not only has this mechanism placed in front of the central nervous system been formed in this fashion, but that the parts of the central nervous system behind it have been formed by physical effects transmitted from the ear through this keyboard where sound is transformed into nervous impulses. Thus also, when thinking

of the semicircular canals, representing as they do the portion of the surface of the body that is still normally excited by just such changes as affected the whole surface of the animal when its habitat was the sea, there is no need to doubt the view that the structures found there were formed by fluid friction; and that the cerebellum was formed as a consequence of the stimuli which have been transformed by these surface organs into nervous impulses.

But if this was the case during the evolution which led up to man, what occurs in the development of the individual? We can afford to admit the possibility that sound may approach the embryo and that fluid friction is responsible for effects observed, but light is obviously no factor in this process. Here there is no doubt that the eyeball is developed into a very perfect optical instrument in the absence of light, and we must ask: What is the force that in this case imitates the action of light? Some force must be held as arranging the several parts of the eyeball in front of the developing retina, and it is probable that before discovering it we should have to refer to the properties of the retina for an answer. We might indeed say that since the retina is a portion of the central nervous system generally characterised by the undoubted possession of electrically charged surfaces, it is always possible that this cause is of an electrical nature. Leave the statement general and it takes the form that the optical mechanisms of the eyeball are formed in the absence of light by some other definite physical cause or series of causes. Place it temporarily in the form where I would like to leave it, both on general grounds and on the evidence that its development is modified by the addition or subtraction of electrolytes: in the absence of light it is probable that orderly electrical forces arrange the developing parts of the eyeball. Now this is really not a surprising statement, since light may probably, even in the first case, be transformed into some other form of energy such as electrical energy when primarily shaping these surfaces. In any case, however, this is the view, that the individual eyeball is an instrument formed probably by some simple set of physical conditions from which light is absent, and that it is used, after a certain abruptly occurring date, by light, a force that has, up to this time, had no access to it, and yet finds it most beautifully formed for its special use.

Now development after all is rather a retrograde affair. Consider the fertilised ovum and its possibilities. A physical condition determines an increase in the chemical activity of the nucleus. A tthe same time an addition is made to the chemical material of the nucleus. The nucleus then divides and forms an ever-increasing site of modified chemical activity. Each new portion of this extending site is surrounded by cell bodies subjected to different sets of physical conditions, and in touch with different qualities and quantities of states. We may take it as certain that not any of the many extraordinary events which take place happen without definite cause. For example, this must be true of every single cell division. Any particular cause bearing similarly on successive generations of cells, or, as we may say, allowed to prolong its action upon a special mass of changing nuclear reaction, must finally produce states of an almost irreversible kind, eliminating possibilities of variation. Thus we might describe the ovum as a possible source of countless variations, whereas it is probable the cells of formed tissues are greatly limited in this possibility. Early in these processes, it is true, a portion of still fairly aboriginal material is shut off, and through some cause protected from changes leading to violent modification; and to this share there still appertains much of the variable character of the original ovum. Part of the remainder, perhaps the whole of the remainder, is under the heavy grip of circumstances which differ widely in different cases, and is step by step slowly driven into something of that deadly monotony of condition which is so evident in the red corpuscle, in the nerve-fibre, and in a somewhat less degree in the nerve cell. Knowing this, then, we shall only with difficulty be induced to credit any particular kind of subordinate cell with any special character. When, for example, it is stated that the mind is, so far as the evidence will permit the statement, associated with the brain, and with no other part of the central nervous system, we can hardly get behind this statement. Mind, in man, is associated with the brain. It is conceivable that in animals it may be associated with parts of central nervous systems so simple in arrangement that we single out nothing from them as the brain. It is also

conceivable that there is something of the kind, indeed, in humble uni-cellular organisms. But in man mind is associated with the brain.

There is also the point that even in the case of the brain such phenomena as sleep and deep anæsthesia familarise us with the fact that the mind is not necessarily always associated with the brain, but only with this when in a certain condition.

Now there is no scientific evidence to support or to rebut the statement that the brain is possibly affected by influences other than those which reach it by the definite paths proceeding from the sense-organs and from the different receptive surfaces of the body. It is still possible that the brain is an instrument traversed freely as the ear by sound, by an unknown influence which finds resonance within it. Possible, indeed, that the mind is a complex of such resonances; music for which the brain is no more than the instrument, individual because the music of a single harp, rational because of the orderly structure of the harp. Consider such a possibility, and the analogy which I have prepared in dealing with the eyeball is seen to have some meaning, inasmuch as an instrument shaped in the embryo by a certain set of conditions may in due course of time become the play of some new influence which has taken no immediate part in fashioning it. I will not dwell upon the point behind this statement, that I find it difficult to refrain from using the word 'soul.'

If, however, such a view is considered it must be said that there is no evidence that any individual physico-chemical phenomenon is developed within the brain that is not developed within other parts of the nervous system, and in a more confused manner indeed within the limits of every living cell. It is some special arrangement of dynamic states that must be held to form the special characteristic of the waking brain, and it should be possible in time to define the peculiarities of those special arrangements whereby we are assuming that the mind is, so to speak, caught.

It is true too that there are great difficulties offered to the expanded presentation of a statement which suggests a mysterious influence provocative of mind as possessed apparently of something of the nature of a physical force, since it is held to be constrained in certain peculiarities of physical environment to behave in a special way. It is indeed almost clear that this influence must be held to affect those physical surroundings since there is little doubt that mind, *per se*, affects human conduct and animal behaviour, just as it is impossible to conceive mind, where present, as exerting no influence in natural selection. This, although the risks of the environment must always play the greater part in natural selection, and the influence of the mind be conceived as only secondarily affecting the organism through the intervention of the nervous system, or through mechanisms that are substituted for that system. Admitting these facts, we should in this case be obliged to regard mind resonating amongst the distributed dynamic states of the brain as influencing them in a way that might possibly be demonstrable in any physical apparatus closely imitating those states and their distribution.

Then, again, one of the main objections to a suggestion of this kind is that the condition might involve a transformation of energy which should have been discovered as an otherwise unexplainable quantity in the energy equations of the body. There may, however, be no real necessity to conclude that any transference of energy would be involved in such a process. The distribution of dynamic states in the central nervous system which are suggested as playing the part of resonators is, as I have already related, a distribution of opposite states. If we consider how these opposite states, excitation and inhibition, are arranged in any given case, it is seen that the installation of an equal number of excitations where inhibitions were present, and of inhibitions where excitations were present, will give rise to a new pattern of a very different meaning. Now such a change in the distribution of states might entail either no more than the transmission of nervous impulses, a process in which exceedingly small quantities of energy are dissipated, or indeed an actual cessation in the transmission of certain nervous impulses, since it is one of the curious features in these states that the one tends to recoil into the other. We might, indeed, make the assumption that an alteration in the setting of the instrument, such as was attended with a change in consciousness, was always attended by this cessation of nervous impulses, so that a brilliant display of mind might be associated with

no increase in the transformation of physical energy, but actually with a diminution in the transformation. Under cover of such an assumption it might be held that this mysterious influence of which I have spoken absorbed instead of contributing energy to the system, or that it diverted energy without loss from one part of the system to another.

Now, in my opinion, there is no one at the present time who is in a position to discuss the energy transformation of the central nervous system. Further, there is certainly no one capable of dealing with such peculiarities as might arise in the energy transformation of that part of it, the brain, which is associated with the mind. There are many points to be cleared up, as, for instance, the extraordinary relationship of the central nervous system to the general muscular system, upon which I might be allowed for a moment to dwell. The fibres of skeletal muscle form the largest site of energy transformation from the oxidation of food or fuel, a site in which apparently no such transformation takes place without a coincident exhibition of characteristic muscle function and the performance of some mechanical work, and are dominated in this transformation by impulses discharged from the ventral portion of the central nervous system. This exhibition of function is invariably the cause of a despatch of nervous impulses into the central nervous system again, along the nerve-fibres passing into its dorsal portion. Now, since the energy set free in muscle is out of all proportion to the small sum of energy transmitted from the nervous system, it is capable, amongst other things, of despatching back again to the central nervous system a compensating or even an additional sum of energy. The musculature might then be supposed to reinforce the nervous system. Until such points are given their due importance it would be ridiculous to dogmatise about the energy equations of the central nervous system, and to discuss the amount of energy expended in the performance of movements, or stored in the absence of movements, within this system.

I will not labour these points, upon which I can throw no light, but put forward this expression of belief rather than opinion, to explain an attitude revealed in the remainder of this address, and not as based on evidence or in any way a statement of demonstrated or demonstrable fact. The essential point for the moment is this—that there is some loophole for the view that mind is not directly associated with life or living matter, but only indirectly with certain dispositions of dynamic state that are sometimes present within certain parts of it. It is a point of view not without interest to physiology, since it would leave that science free to consider all phenomena present in such forms of life and living matter as carry no suggestion of an association with mind, as nothing more or less than physico-chemical phenomena, which, when thoroughly investigated, would be completely translatable into scientific terms. Then, too, when there is evidence of mind, the view is that it represents a force acting from without upon what is still no more than matter involved in certain chemical and physical states. Incidents of function would, in such a view, pass straightway into the realms of physical and organic chemistry, requiring special methods of investigation alone, because of the localisation of processes and punctate states in minute microscopical parts not readily removed from their surroundings into selected experimental surroundings of the same value.

We are at liberty then to deal with this series of physico-chemical experiments, boldly giving each observed difference in circumstance a possible importance in the determination of observed differences of character, and each difference in character a probable explanation in terms of simple differences in circumstance; we may boldly consider the causation of variations, and use the term 'natural selection' as equivalent to the physico-chemical limits to the successful maintenance of each experiment. Let us for example begin with the blood.

It is at once legitimate, in the first place, to ask how this blood tissue has arisen from variation in the chemical reactions of nuclear material. The argument runs that some ascertainable cause must have produced a material variation which has been preserved by natural selection, and quite probably, too, by the persistence of the cause over some long period in the history of nuclear material. There is no harm for the moment in surveying causes, and temporarily fixing upon one that seems to possess greater appropriateness than any other. Therefore I suggest that we take this main characteristic of nuclear material in the blood tissue, that it is engaged in the production of a pigment, and that the

most efficient cause determining pigment production is the action of light. Remembering that we are probably dealing with nuclear matter in general from which this particular material has been split off and set aside by subsequent causes, we can admit this postulate. The pigment-forming propensity of blood is thus taken as probably due to the initial action of light upon nuclear material placed near the surface of the body, and there exposed to the action of light.

Our next step is to discover any probable fact which, favoured by natural selection, might drive into the interior of the body nuclear matter that had been so modified by light that it persisted in the formation of pigment; in other words, Why should any pigment-forming reaction ever be removed from the direct influence of light, and a valuable transformer of radiant energy be thus driven into a position of disadvantage within the interior of the body?

Now let us consider the value of those particular instances of pigment formation which have been allowed by natural selection to persist upon the surface of the body. These successes represent experiments that have not been detrimental to the general mass of chemical reactions which form collectively what we call the organism, and we are entitled to ask, In what way are these successes likely to differ from the failures? If we take the possibility that some pigments convert all the light which they absorb into heat, and receive per unit of surface a share of solar radiation measured as seven thousand horse-power per acre, we have a picture that the body surface might thus be exposed at any one time to the transformation of an excessive amount of energy. The square metre of surface which might in the human body be exposed at one time to the sun would, provided with such pigment, absorb in one hour as much heat as is produced by the whole body in twelve hours, and the temperature of the body might be raised a further 20° C. by this means in one hour. It must then be an important matter in which the risks of life maintenance have certainly acted along the lines of natural selection, that such pigments transforming the total energy they receive into heat must be driven from any place they have temporarily occupied on the surface of living matter. As in the plant, in successful cases this energy must be largely diverted into chemical work. It would not then be surprising that certain modes of pigment formation have been eliminated, and that certain other modes finding a utility of some other kind have been retained by natural selection in seclusion within the interior of the body. Let us take it that blood-pigment represents such a mode of reaction, and that its influence is mainly to convert light into heat, and secondarily in some degree to determine the separation of oxygen from certain compounds, thus also performing some chemical work when under the influence of light.

Now since it is also part of the general line of argument that it was inefficient in this chemical aspect, and on that account driven from the surface of the body, it must be held as incapable of separating oxygen from more stable compounds; and we find an explanation for the fact that it is engaged upon unstable compounds of oxygen, not absorbing much energy in the process of reduction nor liberating much on oxidation.

Since in regard to all such chemically dynamic pigments, with a utility dependent upon their constant association with some molecular group in which a corresponding reduction process can be effected, it will never be surprising to find this group actually forming a constituent part of the molecule. It is, then, not surprising to find these two qualities, pigment and unstable oxygen compound, present in hæmoglobin; nor to find in this special case that the secondary process has assumed the position of major importance, and that hæmoglobin is no longer of use as a pigment so much as an unstable compound of oxygen. Following this line of reasoning, there is nothing extraordinary in the discovery that such pigments utilised as 'oxygen carriers' within the interior of the body are found in other situations than in blood—for instance, in the nerve-cells of certain animals and commonly in skeletal muscle. Blood tissue represents a special set of nuclear reactions possessed of this persistent quality in marked degree.

If it seems strange that the initial formation of blood in the embryo and its maintained formation in the adult persist in the absence of light, let us return to the instance of the eyeball. Of that instrument it was said that although it was originally formed by light, yet in the mammalian embryo its formation was continued in the absence of light. Here it was necessary to

think of some replacement of one cause by another, and not difficult to adopt such a suggestion, since even in the initial process it was probable that light produced its effects subsequent to transformation into some other form of energy such as electricity. In that particular case this idea of forces, and substituted forces, in action, is capable of being formulated in fashion readily understood, because of the ease with which we can think of arrangements in gross parts being determined by such forces. Here in this new case we are, however, thinking of parts of a different order of magnitude, a fact which I can best illustrate by reference to a single red blood corpuscle occupying a one-tenth millionth of a cubic millimetre, and containing in a one hundredth part of that space as many molecules of hæmoglobin as there are present red blood corpuscles in one cubic millimetre of blood—that is to say, five millions.

Now there is in reality no difficulty in considering some electrical agency as limited in its action to the minute dimensions in which each pigment-forming reaction is in process; some electrical machine such as, for example, might be energised by electrons derived from the dissolved molecules of a pigment-salt; such a machine as might be capable of transforming both light and heat into electrical energy, and which would maintain a process in the absence of light at the cost of energy obtained in the form of heat.

When thinking of the persistence of such reactions as this, initiated in this way by the action of certain primary causes that are then subsequently removed without any cessation of the reaction, we are concerned with one of the fundamental properties of living matter. Everywhere in living matter numerous instances of this property are being discovered, as in the study of immunity and of protection from infection. Nor is there reason to believe that this persistent quality of such variations will not finally be explained in terms of physical chemistry. The main characteristic of living matter is that it contains machines formed by electrolytes distributed upon the complex surfaces of matter in a state of colloidal solution, and in the presence of competitive solvents, and that such machines are multiplied within it. Some of these mechanisms are arranged and perfected by the action of physical conditions operative on the surface of living matter, as, for instance, light. Some by energy derived from internal sources, but in a form that embodies conditions originally derived from the surface. Some are primarily due to internal disturbances in the equilibrium of these complex solutions produced by those chemical reactions which take place there.

Now, returning to the grosser characteristics of blood, we find it possessed of other characters curiously reminiscent of the surface of the body, and especially of glandular invaginations from the surface. Thus it is everywhere confined by cells spread upon its surface, the endothelium, which limit its relationship to the general mass of the interior. Its new-formed cells are again passed into an internal core covered by these surface cells, and from this situation, except as a result of violence, they do not pass. We might, in fact, compare the blood with a gland in which the red blood corpuscles were seen as a secretion occupying a lumen which represents the original external surface of the body. I do not wish to lay any emphasis on this point except in so far as it renders clearer this thought: that blood covered by its endothelium represents a single tissue which tends, like any gland, to grow into every interstice of the body, where the conditions of mechanical pressure permit. I shall render the point clearer by saying that the blood capillaries are no more and no less than blood-tissue.

In its early days this blood-tissue, or, if you will, this capillary network, is pushed into each portion of the body by pressure due to its growth. In its later stage, the tissues surrounding it which form the muscular coat of the heart and the walls of the blood-vessels are arranged into an external mechanical system providing a new pressure, which still further tends to push the blood-tissue into every available space, a process such as, for example, takes place in tumour development and in the granulation tissue present in wounds.

It is a general postulate that cells long exposed to constant conditions may come to be stamped by those conditions. Special change takes place from the time when the blood grew onward by pressure of its own growth to the time when this movement is more clearly determined by the mechanism of the circulatory system, and divergent results occur in different localities of the blood-tissues

which can be attributed to the differences in these causes of onward motion. Thus where growth is the leading cause of this progressive motion, as, for example, in the development of bone, the blood-tissue is later found occupying spaces that are cut off from the general mass except by lines of communication too small to transfer a full share of pressure from the circulatory mechanism. In this isolated space the blood-tissues preserve to a greater degree powers of intrinsic growth than in those places where the tissue bears the brunt of new forces. It is true that other factors induced by the new motion given to the fluid core of this tissue complicate this matter. This notwithstanding, it is, however, clear that certain definite differences in circumstance, and those principally of a purely mechanical kind, leave the blood-tissue in one district possessed of aboriginal properties which are in a large degree lost elsewhere.

As to that other tissue, which forms the circulatory system and embraces the blood-tissue, there is here little room for doubt that the structures found are the result of special local conditions acting upon originally similar cells, and little room for the suggestion that samples of several different kinds of special formative cells are driven into those positions by destiny and not by mechanics. This is an old theme, well extended and illustrated by exact observation, especially by Thoma; that in every blood-vessel the arrangement of structures is an almost immediate guide to the conditions of pressure met with in that vessel. Let us proceed through the structures in the walls of a small artery, giving a definite mechanical origin to each tissue. The elastic tissue first met with in the inner coat of the vessel is the result of periodical or intermittent pressure. In the large arteries, where intermittent pressure is the main phenomenon and where its influence is felt right through the thickness of the wall, this elastic tissue has the major share in forming the structure of the wall. In the small artery, where the total quantity of the causative phenomenon is small, the innermost structures are affected most. This inner zone, formed under the influence of intermittent pressure, protects from intermittency the tissue formed by constant pressure, involuntary muscle. Both with regard to this tissue and with regard to the elastic tissue, it is to be remembered that the conformation of the material embracing the cylindrical mass of blood-tissue is such as to convert incidents of internal pressure into tension as well as pressure. Thus we may say that elastic tissue varies in quantity with the value of intermittent, involuntary muscle with the value of constant, pressure and tension. On the outer surface of this case, still more protected by the mechanical value of the structures internal to it, but submitted to the traction and friction of surrounding tissues, comes white fibrous tissue. Again, when windows have been cut in the outermost case of large vessels, leaving the inner case intact, and thus destroying the tensile character of the mechanical conditions and permitting the internal pressure to hammer through these windows, they have been found closed in by plaques of cartilage, and even by true bone. It is true that the explanation offered for such results has been different from that here inferred, it being held that cells specially formative of cartilage and bone have been admitted to this new situation by the brusque strokes of operating instruments. True, too, that the complete ligature of vessels has been followed by developments of bone in unexpected places beyond the walls of the blood-vessels, as in the pelvis of the kidney; but how can you make a better internal hammer and better provide for its constant use than, for example, by tying the renal artery? Let me state it as probable that white fibrous tissue, involuntary muscle, and elastic tissue are produced by tension, whereas bone and cartilage are formed by pressure. If we credit the main statement that they are first formed from originally similar cells by circumstances special to each case, and that the difference lies in the circumstances and not in the cells, together with the statement illustrated in former paragraphs that modifications tend to persist when once introduced, we shall probably get near to the truth of the matter. Now it is impossible to leave this special case of the circulatory system —special because here there is no doubt that mechanical conditions are operative from the earliest days of development and from the first beat of the heart—without touching upon two points: the origination of the heart itself, and the formation of valves.

Picture the blood-tissue in its earliest form as a lacery of networks distributed in a layer throughout the embryo, protected better by the greater

thickness of material covering the central longitudinal axis than at the edges. In the absence of this protection the peripheral parts are subjected to incidents of compression which set pressure-waves travelling along the meshes of this blood-tissue in all directions from the point primarily affected. Since these waves will tend to be reflected within the tissue, we can think of the disturbance caused by them as possessed of a certain periodic recurrence of rhythm determined in its time-relations by the dimensions of the tissue, and as undergoing a tendency to modification as these dimensions are increased. In the earliest stages, whilst the distance from edge to edge is less than one millimetre, giving these waves the very slow rate of one metre per second, we can imagine these periodic changes in pressure exerting their influence upon the tissues enveloping the blood with a frequency of one thousand per second. It is again not difficult to imagine that the protection afforded to the central axial portion, through which each wave must pass in transit from edge to edge, allows us to think of the tissue there as more pressed upon than pressing, so that in this place our attention is directed to the enveloping tissue-cells receiving this rapidly recurring stimulation and being especially affected in the process into a formation of cardiac muscle. Since cardiac muscle resembles so closely in many minute particulars skeletal muscle, which is developed mainly under the influence of electrical discharge from the central nervous system, we must, if consistent, suppose that here, too, the same force is in action. In this, however, there is no difficulty, since it is a simple matter to explain how mechanical pressure may give rise to electrical change, as, for instance, when a nerve is excited by mechanical pressure. There is, however, probably this distinction between skeletal and cardiac muscle—namely, that the electrical stimulus provocative of the latter is of a high frequency and approximates nearer to what I might describe as a constant electrical current. The heart is not by any means the only site of formation of rhythmical contractile tissues, and in these other cases, so far as I am acquainted with them, a similar state of formative conditions may be described. Thus at those points where the conical apices of that second network, the lymphatic system, are forced by pressure of external parts to flow towards certain points in this blood-tissue, rhythmical lymph-hearts are described as developed in these protected sites prior to the final penetration of the blood-tissues, and the forced commingling of lymph with the fluid core of the blood.

Now give the agency that I have described a certain direction, crediting it with a graduated qualitative influence in different parts in correspondence with the date of their formation and with the altering dimensions of the blood-tissue as a whole, and the peristaltic character of the movement subsequently performed by the contractile tissue may be completely explained. Let us then suppose that such a peristaltic contractile mass is formed in these enveloping tissues, and consider how it will affect the blood, again enveloped by its own endothelial cells. When driven forward away through this site, the endothelial covering which at first will slip upon the enclosing heart, later will acquire some attachment by the precipitation of fibrous tissue due to repeated friction. The movement of the endothelial cells is now only partial. They have become describable no longer completely as the surface cells of blood-tissue, and are in a measure the internal covering of the heart, its 'tunica intima.' With each pulsation this intima is dragged onwards to some slight degree behind the blood column to which it originally belonged. There is no difficulty whatever in thinking that valves are necessarily formed at every point where the conditions are such as tend to break up the blood column into separate parts. Indeed we may look particularly at every place where valves are found in the blood-vessels, and see similar factors at work. In the arterial system there is no projection forwards of interrupted columns of blood, nor is this the case in any of those veins in which no valves are found, as notably in those veins that are protected from partially distributed results of external pressure by the rigidity or by some other incident in the conformation of the framework in which they are found.

And now let us turn to the main function of this developing system, which is to drive the blood in continual sequence past tissues that contribute to it and tissues that abstract from it certain chemical materials, and let us select the main incident—namely, the carriage of oxygen from the lungs to other parts. That this is a main incident is clearly shown by the fact that the red corpuscles which form so important a feature in the structure of blood are formed in a

number directly equivalent to this demand, that the blood should be capable of transferring a certain quantity of oxygen. Thus if these structures are lost by hæmorrhage, or rendered less efficient by the presence of carbon monoxide, or when circumstances for the acquisition of oxygen are peculiarly difficult, as on high altitudes, their formation is proportionally accelerated. That negative pressure of oxygen governs blood-production is a statement which will bear some inspection.

Now here we have a function which for its perfect performance is dependent upon another machine, the respiratory mechanism, which in its turn is governed by a different but correlated factor—namely, the carbonic-acid pressure in the blood. In this case we may say that the positive pressure of carbonic acid dominates the quantity of the respiratory activity. It is well known now that this statement has been set on firm ground.

It is interesting, then, to observe how these two mechanisms are brought into exact correlation by the simple fact that the lung surface, a portion of the respiratory mechanism, is formed accurately to a measure provided by the volume of blood despatched from the heart, and therefore probably by that second growth of blood-tissue which I have spoken of as due to pressure from the heart. The surface of the lungs is some eighty square metres. The heart at each stroke sends into the lungs somewhere about 100 cubic centimetres of blood containing red corpuscles within a total surface also of 80 square metres. Here, then, we have a mechanical link connecting these mechanisms that is obviously forged by an incident of use.

Within the central nervous system where development mainly affects the shape and distribution of structures rather than their chemical quality, affecting thus what we might call the geography of the system, interesting geographical facts attest to the same forged linkage of mechanisms. Thus, for example, we have the so-called 'sympathetic system,' offering at first view a curious anomaly to the more usual somewhat segmental distribution of nerve-fibres, since from the region of the cord related to the trunk of the body nerves pass through this system to control tissues placed in the head and in the limbs. This anomalous geographical fact is, however, at once explained when we regard the part played by this sympathetic control in the several parts of the body as merely subservient to the interests of locomotion. Under its influence the eye is set for out-of-door, or, if I might say it, for out-of-cave vision. The heart is accelerated. The glandular organs, with the exception of those useful in times of much exertion and heat production, like the sweat glands, are set at rest or else the motor organs of special importance in their sphere of influence are quietened. Regarding the matter in this light there is an obvious convenience of geographical fact in the situation of this instrument midway between those parts of the central nervous system that are swept at this very time by nervous impulses dominating the movements of the limbs; just as there is some convenience in the chemical linkage which has been discovered between the different parts of this sympathetic system that further tends to permit their unison of activity.

On the other hand, when the muscles are at rest and the condition of the body is of the indoor description, the eye is set for close vision, and various glandular organs are allowed to conduct their functions under the influence of nervous mechanisms placed at some distance from the distributing centres of nervous activities that are used in locomotion.

Doubtless this useful distribution of parts within the nervous system must find an explanation in the same terms as must the dynamic anatomical relation to which I have drawn attention as linking up the respiratory and circulatory systems—namely, the fact that the heart sweeps past the surface of the lungs at each stroke red corpuscles that have the same extent of surface as the lungs. In both cases it is true that the right adjustment of the several parts of this machine has been arrived at as a consequence of use, and that there mechanical linkages are due to circumstances of a purely physical and chemical nature.

In conclusion I might say that these instances have been selected to illustrate my opinion that some of the experiments of greatest interest to physiology are in process of conduction within the normal body, and are to be observed by records imprinted on its structures. In feeling for the keys whereby each set of records may be interpreted it is necessary that someone should frankly

attempt to assign a definite meaning to every incident of structure. That this attempt should be limited by precise thinking goes without saying, and I may be allowed the hope that my transgression outside the realms of precision have not been beyond the tolerance of this Section of the British Association for the Advancement of Science.

The following Reports and Paper were then read :—

1. *Third Interim Report on Anæsthetics.*—See Reports, p. 154.

2. *Additions to the Use of a Chloroform Inhaler.*

By Dr. A. G. Vernon Harcourt, *F.R.S.*

In a report to this Section two years ago the Committee on Anæsthetics 'deprecate the use of apparatus based on the vacuum principle,' and 'consider it essention to any form of apparatus that it should be based on the plenum principle, by which an excess of anæsthetic vapour suitably diluted with air is propelled to an open mask by mechanical means.'

The distinction may be illustrated by an inhaler 'based on the vacuum principle,' which has been used in many thousand cases during the past ten years, and by the same instrument with an addition made more recently fitting it for use on the plenum principle. The addition consists of a forked three-way tube, of which one branch is connected with a bellows and the other two with the chloroform bottle and the air-inlet respectively.

As nearly as may be, the strokes of the bellows, which delivers about 500 c cm. at each stroke, should be made to coincide with the in-breathings of the patient. When the operation would not be interfered with by a mask covering mouth and nose, a loose mask may be used, and in the opposite case tubes entering mouth or nostrils only.

By the use of bellows the information which the valves give as to the frequency and strength of a patient's breathing is lost, and the working of bellows makes an additional demand upon attention. Those who have trusted to the breathing of a patient when administering chloroform through a mask may wish to do so still. They will be less deterred from doing so by the adverse verdict of the Committee if they examine the 'First Experiment' quoted as 'sufficiently illustrating the ease' with which dyspnœa can be produced in the human subject by slight obstruction. They will find that the cause of the dyspnœa was the broad 1-inch tube, not by its obstruction, which as compared with that of the nostrils is indeed slight, but by its capacity, which makes the total dead-space exceed the volume of respiration, so that the expired air, with but little addition of fresh air, was breathed again and again. Had the customary half-inch tube been used, the obstruction would have been greater, but the additional dead-space only one-quarter as great, and there would have been no dyspnœa.

The second addition is that of an oxygen-bottle connecting through a valve with a conical reservoir of about 250 c.cm. capacity. The outlet of the reservoir connects with the chloroform bottle and the air-inlet. For use, the tap of the oxygen-bottle is turned on till the valve through which the oxygen passes is lifted at the end 2 or 3 mm. above its seating. Oxygen is then entering the reservoir at about half the ordinary rate of inspiration. This continues during expiration, at the end of which period the reservoir is nearly full of oxygen mixed with some air. During the following similar period of inspiration the oxygen flowing from the bottle is inspired together with that in the reservoir; after which the process repeats itself. With oxygen as with air a dose of chloroform may be given which is immediately variable at will from 0 to 2 per cent. The reservoir prevents the waste, otherwise unavoidable, of more than half the oxygen.

The third addition to the use of the inhaler is to use the same apparatus for administering oxygen only. For this purpose water, kept warm by the night-light below, would take the place of chloroform, and the pointer on the arc would be so turned that the air-inlet was closed and all that was inhaled passed

through the bottle. If it were desired to give air enriched with oxygen instead of nearly pure oxygen, this could be done to any extent by reducing, under the guidance of the valve, the flow of oxygen from the bottle.

Oxygen as it comes from the bottle is said to be cold from expansion, though this effect must be more or less neutralised by friction in the narrow outlet and conduction from the massive valve. Probably the temperature of the issuing gas is lower the greater the rate of exit. The oxygen is certainly dry and will be fitter for respiration after passing over warm water. Also, through the action of the reservoir, the bottle will last more than twice as long.

3. *Interim Report on Body Metabolism in Cancer.*—See Reports, p. 171.

4. *Report on the Dissociation of Oxy-Hæmoglobin at High Altitudes.* See Reports, p. 153.

5. *Report on the Ductless Glands.*—See Reports, p. 172.

6. *Interim Report on the Effect of Climate upon Health and Disease.*

7. *Report on Electromotive Phenomena in Plants.*—See Reports, p. 173.

8. *Report on Mental and Muscular Fatigue.*—See Reports, p. 174.

9. *Report on the Occupation of a Table at the Zoological Station at Naples.* See Reports, p. 119.

10. *Report on Tissue Metabolism.*—See Reports, p. 172.

FRIDAY, SEPTEMBER 1.

Discussion on Inhibition. Opened by Professor C. S. SHERRINGTON, *F.R.S.*

(ii) *Rhythmical Stimulation of Cooled Frog's Nerve. By* Dr. J. TAIT.

(iii) *Conduction between Muscle and Nerve, with special reference to Inhibition. By* Dr. KEITH LUCAS.

The following Papers were then read:—

1. *On Heat Coagulation of Proteins. By* HARRIETTE CHICK, *D.Sc., and* C. J. MARTIN, *M.B., D.Sc., F.R.S.*—See Reports, p. 281.

2. *The Frequency of Colour-blindness in Men.*
By F. W. Edridge-Green, *M.D., F.R.C.S.*

Owing to the imperfect methods which have been adopted the percentage of colour-blindness has been much underestimated. Holmgren gave the percentage of the colour-blind as 3·25, but I find at least 6 per cent., and 25 per cent. have diminished colour-perception compared with the remaining 75 per cent. The definitely colour-blind include the dichromic, the trichromic, those who have much shortening of the red end of the spectrum, and those who are unable to distinguish between colours when the image on the retina is diminished in size. Those who have diminished colour-perception include, in addition to the above, the tetrachromic, the pentachromic, and those who have shortening of the violet end of the spectrum, or slight shortening of the red end of the spectrum.

MONDAY, SEPTEMBER 4.

Discussion on Ventilation in Confined Quarters, especially in relation to Ships.

(i) *Introductory Remarks by* Leonard Hill, *M.B., F.R.S.*

Carbonic acid up to three to four per cent. of an atmosphere has no noteworthy physiological effect excepting that it deepens the breathing. Smaller percentages of one to two per cent. are of no account. The breathing of six per cent. produces headache, palpitation of the heart, sweating, and the breathing becomes distressing. Higher percentages, eleven to twelve per cent., produce coma, but do not quickly destroy life. The partial pressure of CO_2 in the pulmonary alveoli and the concentration of acid (hydrogen ions) in the blood is kept constant by the automatic regulatory action of the acid in the blood on the respiratory centre of breathing.

An atmosphere containing one to two per cent. of CO_2 simply deepens the breathing to such a degree as to keep the acid concentration in the blood constant. Thus, apart from the extra breathing, carbonic acid has no effect on the body (Haldane). Diminution of the partial pressure of oxygen by one to two per cent., and even by three to four per cent., of an atmosphere, also has no effect, as we see by the fact that men live in health and vigour on high mountain plateaux where the partial pressure of oxygen is reduced by one-quarter or even one-third. The great affinity of hæmoglobin for oxygen enables man to wander through wide variations of barometric pressure, to quarry mines, and build railways, and execute some of his greatest works at a height of fifteen thousand feet in the Andes. Martin Flack and myself have investigated the composition of the air in the sleeping-chamber of rats. If it is cold outside, the rats prefer to sleep in air containing as much as four to five per cent. CO_2 and only fourteen per cent. O_2. If the sleeping-chamber is hot and moist, the rats come outside. The discomfort and depressing effect of badly ventilated dwelling rooms, workshops, schools, and meeting-houses has, therefore, nothing to do with the chemical purity of the air, so far as concerns CO_2 and O_2, and Haldane has disproved by exact experiment the existence of any poisonous organic chemical matter in the exhaled breath. The ill-effects are mainly due to the effect of the close air on the temperature regulating mechanism and cutaneous nerves. The only reason for maintaining a high standard of chemical purity of the air of dwelling and working rooms is to prevent unpleasant smells arising from dirty clothes, sweat, and floors, and to keep down the mass influence of infecting bacteria.

Too much importance has been paid to the chemical purity of the air, and not enough to the temperature. It is most necessary to maintain the coolness and movement of the air, for this promotes the metabolism and activity of the body, and by stimulating the cutaneous nerves keeps up the tone of the body.

Our immunity to disease depends on the quality of the blood, and the supply

of blood to, and of tissue lymph which transudes from the blood vessels into, each part of the body. The quality of the blood depends on the foodstuffs digested and absorbed into it, and on the mutual interaction of the organs which elaborate and purify the blood. The blood is circulated not only by the pumping action of the heart but by each muscular movement and change of position, for the valves are set cunningly in the veins, so that each and every movement sends the blood swirling onward in its course. Above all, the breathing movements forward the flow of blood from the organs of the belly to the heart.

Now the activity of men engaged in sedentary indoor occupations depends very largely on the temperature and humidity of the air. If the air is over warm, windless and moist, we are slack, and losing less, we produce less heat. So we come to eating less and breathing less. The organs of the body then have a more restricted choice of building stones from which to elaborate the blood, and the blood moves in more sluggish streams through the outlying territories of our bodily world. Thus our first line of defence is weakened. If the air is cool and moving we are braced up and are active, eat more and breathe more. The blood is refined out of a large choice of foodstuffs, and the organs receive an ampler supply of the rarer and more precious of the chemical complexes—the building stones into which the digestive juices break down the foods. More oxygen is taken in, the daily turnover of the body factory is enlarged, and the blood which barters the rich merchandise of the organs one with another moves in ampler and quicker streams.

Our feelings of vigour and well being depend, too, on the ceaseless in-flow of sensations from the sense organs. Taking a great part in the conscious term of these sensations are those from the skin. The cutaneous sense organs are influenced by the temperature, and by the relative humidity of the air, which controls the evaporation of moisture from the skin, and the passage of tissue lymph from the blood into the skin, and this influence has potent effect on our mental state. A warm, moist atmosphere brings much blood into the skin and depletes the viscera which perfect the blood, and robs the brain of an ample flow. The humidity and temperature of the air affects the mucous membrane of the nose and respiratory air-way, and the evaporation from and flow of tissue lymph through it, factors which must control largely both our comfort and varying immunity to catarrhal infections.

In battleships the great difficulty is to secure a good ventilation without excessive cooling of the individual. The space is confined, and the men next the ventilating orifices, feeling cold, shut them up. The conditions are such that a man with tubercle bacilli in his sputum is very liable to infect others whose natural immunity is deficient. The mass influence of the dose must tell heavily here. In small fishing-boats the men shut up the cabin and sleep in air in which the lamp may finally go out from want of oxygen (less than 17 per cent.). Men with tubercle ought at once to be weeded out of battleships. The introduction of the electric fan in India has increased the power of the European to sleep and work beyond measure. I believe every employer and benefit society would find it pay both in increased output of work and lessened loss from ill-health, if every factory and workshop were brought below 60° F. and well swept with currents of air. We accustom ourselves to live in rooms that are too warm.

I visited recently the Leo Road London County Council school, where every room is swept with a gentle current of air at 57° to 60° F. by a plenum system. The courteous headmaster told me the lost attendances from infectious diseases were fewer than 1,000 per year, while in other schools they reach 10,000 and more. The rooms felt cool and pleasant, and the children and masters appeared fresh at 4 P.M. The parents say the children eat more when they come to school.

Haldane has insisted on the necessity of paying attention to the wet-bulb temperature in factories and mines. This applies also to ships. The wet-bulb should not exceed 75° F., and must be kept below 70° F. For high wet-bulb temperatures a better current of air must be supplied. I have enclosed half a dozen students at a time in an airtight chamber containing about 3 c.m. of air. After about half-an-hour the CO_2 has risen to three or four per cent., and the temperature has reached about 85° F. wet-bulb. The men are then very greatly relieved by putting on electric fans in the roof, which whirl the stationary stale air in the chamber and cool their bodies.

I find that while raising the percentage of CO_2 suddenly from one to two per cent. has no appreciable effect in increasing the discomfort, putting the fans on or off makes a very great difference. The stationary air entangled between the bodies of the men becomes warmed to body temperature and saturated with moisture at body temperature. They cannot lose heat by radiation to each other. The skin becomes warm, flushed, and bathed in sweat. Putting on the fans whirls the air round and brings the cooler air (at 85° F.) in contact with the body, and so promotes loss of heat by evaporation of the sweat and convection. Benedict has kept men for twelve days in his calorimeter with a very deficient ventilation current. So long as the chamber was kept cool they kept in health and comfort, worked hard, and had no sense of closeness.

Carrying out a series of work experiments in our chamber with Messrs. R. A. Rowlands and H. B. Walker, I find the pulse frequency is more accelerated during the work and takes longer to slow down again when the fans are off than when they are on. The pulse frequency depends on the wet-bulb temperature, and the CO_2 percentage makes relatively little difference to it. The breathing volume, on the other hand, depends chiefly on the CO_2 percentage.

(ii) *Ventilation in Confined Quarters.* *By* Professor N. ZUNTZ.

Dr. Leonard Hill in his introductory remarks refutes the idea of the harmful action of carbonic acid up to three or even four per cent. of the atmosphere, and he also attributes no importance to any substances exhaled by the organism together with the carbonic acid. I can agree with this view in so far as the great number of positive data on the poisonous action of the exhaled products of living animals is opposed by excellent experiments in which no sort of noxious effect could be demonstrated. This innocuity seems well proved for man by the experiments of Benedict in Atwater's respiration calorimeter. On the other side, noxious effects have been stated in guinea-pigs—that means in animals whose bowels are the seat of intense fermentations. The idea that the products of those fermentations may be poisonous in some cases is supported by the fact that there exist diseases in man which are considered as caused by poisonous substances absorbed from the intestines. Why may not one or another of those poisons be volatile, as SH_2 is? Moreover, one may object against the conclusiveness of Benedict's experiments, that he circulates the air of his chamber through great vessels containing concentrated SO_4H_2. This acid may destroy the volatile toxins of the air and so keep their quantity on a low innocuous level.

For some years I have considered in my lectures on the hygiene of domestic animals the prevention of excessive moisture of the air in stables as the most important aim of ventilation. But I have not only had in mind that special point, the importance of which Dr. Hill has explained so clearly—that is, the prevention of a sufficient cooling of the body when the evaporation from the skin is interfered with by the saturation of the air with vapour. As soon as the air is saturated there begins a condensation of water at the cooler parts of the walls. This condensation obstructs the capillary pores of the walls and diminishes the ventilation through them. So the removal of moisture is interfered with more and more, and a vegetation of bacteria and mould sets up in the walls and produces noxious gases and vapours. The same thing often happens in newly built houses, when they are inhabited before the hydrate of lime has been changed into carbonate.

If we ask, now, how to provide for the ventilation of a room to prevent the condensation of vapour, we may make the following calculation. A man excretes in twenty-four hours *in minimo* 800 gr. CO_2 and 1,000 gr. H_2O vapour, that means at a pressure of 760 mm. = 400 litres CO_2 and 1,200 litres H_2O. If the ventilation would keep the content of CO_2 in the confined air as low as 0·3 per cent., the quantity of vapour added to the moisture of the entering fresh air would be one per cent., that is 7·6 mm. tension of the vapour. This added to that of normal outside air of medium temperature would bring its humidity near the point of saturation. So we understand that the limit of CO_2 content, which Pettenkofer empirically found to be consistent with the feeling of euphoria of the inhabitants of a room, is really that limit at which the danger of condensation of water at the walls begins.

Now we easily understand that a much larger quantity of CO_2, up to two per cent., produced no inconvenience in Atwater's respiration chamber, where the moisture was continually condensed by the heat absorbers, which keep the temperature of the chamber on a constant level. In the result we cannot agree totally with Dr. Hill's conclusion that movement of the inside air by fans, which cools down the temperature of the skin, may replace normal ventilation with fresh air. Such action of fans will certainly elevate the efficiency of the included working men to normal height for some hours. But if we wish to keep the room in a sanitary state, we must either increase the fresh-air ventilation to the standard prescribed by Pettenkofer, or we must condense and eliminate the overplus of moisture by cold surfaces, as is done in the apparatus of Atwater.

The following Papers were then read:—

1. *Heat Production and Body Temperature during Rest and Work.*
By Professor J. S. MACDONALD *and* Dr. J. E. CHAPMAN.

2. *Certain Physical Questions regarding Blood-vessels and Blood-cells.*
By JOHN TAIT, *M.D., D.Sc.*

Lister showed the cause of blood coagulation to be contact of the blood with (chemically) inert materials, such as glass, wood, hair, &c. The physical property in virtue of which these substances excite coagulation became for the first time clear when Freund discovered that contact of blood with greasy substances, such as vaseline or oil, does not produce clotting. In order that clotting may occur blood must come in contact with a material to which it can adhere. As Freund himself suggested, blood remains fluid in the blood-vessels because the lining endothelium is physically so constructed that adhesion between it and the blood is negligible.

When the aorta of a recently killed rabbit is slit open longitudinally and pinned out flat, one can readily see, by pouring defibrinated blood of the same animal over the inner surface, that to certain patches at least the blood does not adhere. Mr. J. A. Hewitt and the present author have found that a scraping of vascular endothelium removed on the blade of a knife becomes jet-black when exposed to the vapour of osmic acid. They have also estimated the amount of ether-soluble material in the dried aortic endothelium of the ox, and discovered the presence of as much lipoid as in the dried stromata of red blood corpuscles. There is thus as much justification for considering vascular endothelium a lipoid lining as there is for considering the envelope of red blood corpuscles of lipoid nature.

This fact may be of importance in relation to problems in hæmodynamics, to problems of absorption through capillaries, to the combined hæmorrhagic and hæmolytic action of certain snake-venoms and to the frequent association of certain hæmorrhagic and lymphatic diseases with hæmoglobinuria, *i.e.*, with hæmolysis. (From the fact that blood does not necessarily clot when brought in contact with the serous membranes of the body, it is probable that serous endothelium, and possibly the endothelium of the lymph-vessels, is likewise rich in lipoid.)

Certain cells of the blood, *e.g.*, the spindle-cell of Sauropsida and Ichthyopsida, and the amœbocytes[1] of invertebrates, adhere firmly to substances like

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[1] The alleged 'amœboid' movement of colourless invertebrate blood-corpuscles, which have been placed on a glass slide, is merely a spreading out of the corpuscle, like the spreading of a rain-drop on a stone. The so-called pseudopodia, once extruded, are never withdrawn again. The movement is a progressive expansion due to the adhesion of the glass, and in thus being irreversible is no true amœboid movement.

glass, or wood or cotton fibres, all of which are of a non-greasy nature. Such cells have been shown to be highly phagocytic for particles of Indian ink or carmine. Indeed, among the various forms of invertebrate cells those which possess in highest degree this phagocytic power for Indian ink particles are precisely those which flatten out most promptly on glass. The phagocytosis of such particles is a purely physical phenomenon conditioned by the greater attraction of cell molecules over plasma molecules for the particle in question. A minute fragment of Indian ink, having accidentally come in contact with the cell, the cytoplasm simply creeps over it, displacing the plasma until the fragment is engulfed. Cells such as these, which phagocyte Indian ink particles have no power to phagocyte fat particles present in a fine emulsion.

The process of diapedesis of leucocytes may possibly be explained on similar principles. Arnold showed that diapedesis occurs at certain spots situated at the junction of the endothelial cells, where presumably some of the extra-endothelial tissue is temporarily exposed. To this the cell adheres. Because of the molecular attraction between cell substance and the fluid or semi-fluid extra-endothelial material, the surface tension of the cell is locally reduced over the adhering area, whereas it remains relatively high over the portion still covered by plasma. The consequence is that the cell is forced continuously outwards.

3. *Nutritive Values of Wholemeal and White Flour.* *By* Miss May Yates.

TUESDAY, SEPTEMBER 5.

The following Papers were read :—

1. *On the Influence of Iodoform, Chloroform, and other Substances, dissoluble in Fats, on Phagocytosis.* *By* H. J. Hamburger, *Sc.D., M.D., LL.D.*

In the last four years I have occupied myself with Messrs. E. Hekma, J. de Haan, and F. Bubanovic on the physiology of phagocytes.[1] The present paper forms a continuation of these investigations, but has a pharmacological point of issue. For the last thirty years iodoform has been successfully applied in the treatment of wounds and chronic inflammations. Several hypotheses have been suggested to explain its favourable action, but none of them have proved to be generally satisfactory.

Having observed in what small quantities calcium could accelerate phagocytosis, the idea came to me that *iodoform might have the same effect.*

The method of investigation adopted corresponded entirely to that we followed in former researches. We settled the percentage of leucocytes, having taken up carbon in case of addition of iodoform, and without this, to the 0·9 per cent. NaCl-solution.

The results were not doubtful; iodoform promoted phagocytosis to a considerable extent. *The effect was still plainly visible in a fluid containing* 1 gr. CHI_3 to 5,000,000 c.c. NaCl-solution 0·9 per cent., or 1 *gr. mol.* CHI_3 *to* 1,900,000 *L. of the NaCl-solution.*

What could be the reason of this acceleration? We may take it for granted from numerous investigations that the outer layer of cells consists in a fat substance, a so-called lipoid membrane. Further, it is a well-known fact that iodoform is soluble in fat. Now it is obvious that by taking up iodoform the lipoid membrane will grow more flexible; in other words, the surface tension will decrease and consequently the amœboid motion will be facilitated. Hence an acceleration of phagocytosis. If this interpretation was the correct one, then it might be expected that other substances which are soluble in fat would affect

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[1] Cf. *Biochemische Zeitschr.* and *Proceedings of Royal Society Amsterdam.*

phagocytosis in a similar way. So we made experiments with *chloroform, chloral, camphor, benzine, turpentine,* and *balsamum peruvianum. All these substances promoted phagocytosis to a very considerable extent.* For instance, chloroform was seen to accelerate phagocytosis even in a concentration of 1 to 5,000,000. In a concentration of 1 to 500,000 the increase of phagocytosis amounted to 43 per cent. In stronger solutions this value was smaller, and the stronger the solution the more the accelerating effect diminished. This must be attributed to a second factor coming into play, viz., paralysis of the protoplasm-motion, which factor manifests itself but little in a very weak solution. Benzine was found to have the most favourable effect on phagocytosis in a dilution of 1 to 100,000. Generally this concentration depended upon the relative solubility of the substance in fat and water (Teilungscoëfficient).

Our results correspond entirely to those observed by *J. Loeb* in the artificial fertilisation of the eggs of the sea-urchin and the starfish. By allowing, namely, substances, dissolving fat, to act upon these eggs he could effect the development of those into larvæ. However, it must be noticed that other substances promoting this development, such as digitaline, strophantine, saponine, did not affect phagocytosis. We only observed an acceleration by substances soluble in fats.

Probably we have to do here with a phenomenon of general bearing. Even plant-cells were seen to conduct themselves in the same way. *So we succeeded in promoting the germinating of wheat grains by small quantities of chloroform.* Evidently we must think here of a greater activity of cell-division, caused by softening of the lipoid membrane.

2. *On the Physiology of Gas Production in connection with the Gas Bladders of Teleostean Fish.* *By* W. N. F. WOODLAND, *D.Sc.*

The gaseous contents of the bladders of Teleostei are found on analysis to consist for the most part of a mixture of oxygen, nitrogen, and carbon dioxide, these constituents of the mixture being present in very different proportions in different species of fish. According to the most recent and best established view of the subject, these three gases are extracted from the blood stream and transferred to the bladder cavity by the squamous cells composing the lining epithelium of the bladder. In the case of those gases which are only present in small quantity in the bladder, their presence may be accounted for by the assumption of a simple process of diffusion from the blood stream, but when a particular gas is present in the bladder in such quantity as to exert a pressure many times greater than that exerted by the same gas in the blood, it is necessary to assume that the cells lining the bladder exert a pumping action. *E.g.,* the bladders of many freshwater (Cyprinidæ, *e.g.*) and some marine (*Exocœtus volitans,* the flying-fish, *e.g.*) fish contain as much as 94 per cent. of nitrogen, exerting a partial pressure many atmospheres greater than the pressure of the nitrogen present in the blood. Bladders containing nitrogen and carbon dioxide to the practical exclusion of oxygen secrete these gases by means of the ordinary cells lining the bladder cavity, but bladders containing a considerable percentage of oxygen (and in some the contained gas consists of nearly pure oxygen) always possess a special development of the lining epithelium termed the gas or oxygen gland. This gas gland consists essentially of a local proliferation (folded or massive in type and very varied in form) of the enlarged and columnarised epithelial cells, each of which is in contact at one end with the thin endothelium of a blood capillary and at the other with the bladder cavity or a duct leading into it. In constant association with the gas gland is the *rete mirabile duplex,* a structure which is of as much importance for the filling of the bladder with oxygen as the gas gland itself. The rete mirabile consists of the intimate intermingling of the two sets of fine capillaries formed by the subdivision in the same region of the body of the artery and vein which supply the gas gland—the artery breaks up into a bunch of hundreds of fine capillaries carrying blood of course to the gland, and closely intermingled with these are the equally numerous and fine capillaries of the vein returning the blood from the gas gland. This rete mirabile may be bipolar—*i.e.,* the arterial capillaries at the end of the rete next the gland may unite into a few large vessels before again subdividing

to form the capillaries supplying the gas gland, the venous capillaries uniting in a corresponding manner, or unipolar, the arterial capillaries of the rete directly supplying the gas gland cells and the corresponding venous capillaries returning from the gland at once mingling with the arterial capillaries without first uniting into a few large veins. The essential feature of the rete mirabile is the *intimate intermingling and juxtaposition (not inter-communication) of the two sets of capillaries carrying blood in opposite directions.* The author has published[1] a full account of the structure of these gas glands and their associated retia mirabilia in various teleosts, and also certain suggestions as to the use of these organs, based upon the facts described by Bykowski, Nusbaum, Reis, himself, and other investigators. In brief, the general theory proposed was as follows:—

In the supply of oxygen to the ordinary tissues of the body the gas is, of course, combined with the hæmoglobin of the red blood corpuscles, and is only liberated from this combination into the blood plasma as the partial pressure of the oxygen already dissolved in the plasma is lowered by absorption of the oxygen by the tissues. Now the cells of the oxygen gland differ from the other tissues of the body in that, being already employed in pumping oxygen into the bladder, they are in no special need of it for metabolic purposes, and even if they were able to abstract the oxygen from the blood plasma in the same way that other tissues do, this method of abstraction would be quite inefficient in view of the fact that the oxygen required by the gas gland must be abstracted both in relatively large quantity and at a relatively rapid rate. The necessity for this rapid production by the gas gland of large quantities of oxygen will be evident on realising the further fact, proved by numerous experiments, that oxygen (doubtless in virtue of its abundance in arterial blood and its ready absorptibility) is the only gas employed both for the sudden increased production of gas in the bladder required when a fish sinks in water and so experiences great increase of pressure, and for the sudden abstraction of gas (the oxygen re-entering the blood stream through the 'oval' when this structure is present in the bladder wall) necessitated by the rising of a fish, the body of which thereby experiences diminution of pressure. Available evidence thus points to the fact that the presence of oxygen in the bladder connotes the habit on the part of the fish of migrating in a vertical direction in deep water; in the case of those fishes which do not change their depth to any appreciable extent (*e.g.*, the marine flying-fish and many fresh-water fish, including a few living at considerable depths) the bladder is filled with gases which do not require to be produced quickly—nitrogen and carbon dioxide—and could not be if required owing to the small amount present in the blood, the oxygen of the blood in these cases being reserved for respiratory purposes. It is considered extremely probable by some authorities that the method by which the gas gland forcibly abstracts the oxygen from the arterial blood is by the secretion of a 'toxin' (Jaeger) on the part of the gas gland cells. This toxin is poured into the blood traversing the capillaries of the gland, where it effects partial hæmolysis, the erythrocytes being broken up and their contained oxyhæmoglobin dissolved in the plasma. This dissolved oxyhæmoglobin is then abstracted by the gas gland cells, which thus seize upon the prime source of the oxygen in the blood in place of the weak solution of oxygen in the plasma supplied to ordinary tissues. In the author's opinion the rete mirabile was for the purpose of enabling the toxin to act upon the arterial blood *before* it comes into contact with the gas gland, so that by the time the blood reaches the gland the oxyhæmoglobin shall be already dissolved in the plasma and so available for abstraction by the gland cells. On this view the gland pours the hypothetical toxin into the blood, which, returning from the gland, subsequently traverses the venules of the rete; during its course in the rete the toxin diffuses from the venules into the adjacent arterioles where it produces hæmolysis of the arterial blood, a process which effects the solution in the plasma of a quantity of oxyhæmoglobin by the time the arterial blood reaches the gas gland.

Recent experimental work, however, conducted at the Plymouth Marine

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[1] *Proc. Zool. Soc. Lond.*, vol. i., 1911.

Biological Laboratory has not confirmed the general theory above outlined. Numerous observations made on the active gas glands and retia of the pollack, conger, mullet, and other fishes have apparently disproved the suppositions that the gas gland cells form intracellular *gas* bubbles, that a lysin is secreted to effect hæmolysis in the rete capillaries, and that oxyhæmoglobin is absorbed by the gas gland cells. The obvious appearances of hæmolysis occasionally to be seen in sections of the capillaries of the gas gland and rete (figured by Bykowski and Nusbaum and the author) are difficult to explain (the fixation of the material being good), but in view of the recent observations referred to, cannot at present be relied upon as evidence of a natural process. The whole subject of the physiology of the gas gland is in urgent need of extended inquiry.

3. *An Attempt to obtain Photographic Records of the Emigration of Leucocytes.* *By* W. W. WALLER.

4. *The Carbon Dioxide Output during Decerebrate Rigidity.*

By H. E. ROAF, *D.Sc.*

The object of these investigations was to determine whether the rigidity of the muscles produced by removal of the cerebrum was accompanied by an increased production of carbon dioxide. The animals were anæsthetised and decerebrated. After the removal of the brain, artificial respiration was maintained, and the weight of carbon dioxide excreted was measured. The external conditions were maintained as constant as possible. Each experiment was divided into two periods, the first with the muscles rigid, and the second after removal of the rigidity.

The internal temperature and weight of the animal affect the amount of carbon dioxide given off. A fairly constant figure is obtained by the use of the following expression :—

$$\frac{\text{Carbon dioxide given off} \times (2{\cdot}5)^{\frac{40-t}{10}}}{\sqrt[3]{\text{weight}}}$$

Excluding those experiments in which muscular movements occurred the average figure for twenty-three experiments, by the above expression, is 1·705 ± 0·026. Abolishing the rigidity by intravenous injection of curare gives as an average for eleven experiments 1·669 ± 0·049. This is a lowering of 0·036, but the probable error of the difference is 0·056. Therefore abolishing the rigidity by curare does not diminish the output of carbon dioxide.

Cutting the motor nerves to all four of the limbs removes the rigidity, but does not appreciably lower the carbon dioxide output.

The total carbon dioxide production from the limbs is not greater than the carbon dioxide output of the same weight of resting muscle as given by Barcroft.[1] Decapitation and cutting of the spinal cord both cause a decrease in the amount of carbon dioxide excreted. Cutting the splanchnic nerves does not lower the output of carbon dioxide. Therefore the muscular rigidity, produced by decerebration, differs from ordinary muscular contraction, because it does not involve an increase in the output of carbon dioxide. Cutting the cord does lower the carbon dioxide output. This, as shown above, does not seem to be due either to removal of muscular rigidity or to lowering of the blood pressure.

5. *The Claim of Sir Charles Bell to the Discovery of Motor and Sensory Nerve Channels (an Examination of the Original Documents of* 1811 *to* 1830). *By* AUGUSTUS D. WALLER, *M.D., F.R.S.*—See Reports, p. 287.

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[1] *Erget. d. Physiol.*, vol. vii., 1908.

6. *On Paramnesia. By* Professor GEORGE J. STOKES, *M.A.*

Having given an account of the phenomenon, drawn from personal experience, but agreeing with that given by Dr. Maudsley, the author discussed different theories which have been, or may be, put forward to explain it: (1) The Inheritance theory; (2) the Double Brain theory; (3) the Inverted Hallucination theory. Criticism of these theories, Professor Baldwin's criticism of the Double Brain theory.

Suggested explanation: In accordance with the Neuron theory we may conceive that intimations of a present phenomenon may reach the central consciousness by more channels than one. Not exactly the whole phenomenon, but aspects of it, may be conveyed by other and devious routes. It is as if some news were being forwarded by the regular official channel; meanwhile we get a hint by private wire. Hence the prophetic certainty. These private intimations do not come to us direct from the senses, but through neurons, with which memories are usually correlated. Hence this illusion of memory.

Section K.—BOTANY.

President of the Section.—Professor F. E. Weiss, D.Sc.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

Greatly as I prize the honour done me by the Council of the British Association in electing me to the office of President of the Botanical Section, my gratification has been heightened by the knowledge that the meetings of this section would be graced by the presence of the distinguished group of Continental and American botanists who have just taken part in the International Phytogeographical Excursion to the British Isles.

I am sure that I am voicing the unanimous feeling of the Section in offering them a hearty welcome to our deliberations, and, in conveying to them our sense of the honour they have done us by their acceptance of the invitation of this Association, I would like to express our hope that by their participation in our proceedings they will help us to promote the advancement of botanical science, for which purpose we are met together.

In view of these special circumstances under which we foregather, it may seem inappropriate if I deal, as I shall be doing, in my Presidential Address mainly with fossil plants, with the study of which I have been for some time occupied; but I need hardly assure our visitors that, while we entertain some feelings of satisfaction at the contributions made during the past half-century towards our knowledge of extinct flora of Britain, yet, as the later sittings of this Section will show, and as they have no doubt realised during their peregrinations through this country, our botanical sympathies and energies are by no means limited to this branch of botanical study. Moreover, I hope during the course of my address to point out the ecological interest which is afforded by certain aspects of Palæobotany.

On the sure foundations laid by my revered predecessor, the late Professor Williamson, so vast a superstructure has been erected by the active work of numerous investigators that I must limit myself in this address to exploring only certain of its recesses; and I shall consequently confine myself to some aspects of Palæobotany which have either not been dealt with in those able expositions of the subject given to this Section by previous occupants of this presidential chair, or which may be said to have passed since then into a period of mutation.

The great attractiveness of Palæobotany, and the very general interest which has been evinced in botanical circles in the progress of recent investigations into the structure of fossil plants, are due to the light they have thrown upon the relationship and the evolution of various groups of existing plants. It was the lasting achievement of Williamson to have shown, with the active co-operation of many working-men naturalists from the Lancashire and Yorkshire coalfields, that the structure of the coal-measure plants from these districts can be studied in microscopic preparations as effectively as has been the case with recent plants since the days of Grew and Malpighi. Indeed, had Sachs lived to continue his

marvellous historical account of the rise of botanical knowledge up to the years 1880 or 1890, he would undoubtedly have drawn attention to the remarkable growth of our knowledge of extinct plants gained by Binney and Williamson from the plant remains in the calcareous nodules of English coal-seams, and by Renault from the siliceous pebbles of Autun. We are not likely to forget the pioneer work of these veterans, though since then investigations of similar concretions from the coal deposits of this and other countries have been undertaken by numerous workers and have revealed further secrets from that vast store of information which lies buried at our feet.

The possibilities of impression material had indeed been practically exhausted in 1870, and further advance could only come from new methods of attacking the problems that still remained to be solved. The most striking recent instance of the insufficiency of the evidence of external features alone was Professor Oliver's demonstration of the seed-bearing nature of certain fern-like plants, based on microscopical comparison of the structure of the cupule of Lagenostoma with the fronds of Lyginodendron, after which discovery confirmatory evidence speedily came to hand from numerous plant impressions examined by Kidston, Zeiller, and other observers.

Undoubtedly in the hands of a less competent and far-sighted observer than Williamson, the new means of investigation might have proved as misleading as the old method had been in many instances. Indeed, as is well known, the recognition in the sections of Calamites and Sigillarias of the presence of secondary wood had caused Brongniart to place these plants among conifers, owing to his belief that no Vascular Cryptogams exhibited exogenous growth in thickness. It required all Williamson's eloquence and pugnacity to convert both British and French palæobotanists to his views, ultimately accepted with such handsome acknowledgment by Grand' Eury, one of his antagonists, in his 'Géologie et Palæontologie du Bassin Houiller du Gard.'

It is curious that Grand' Eury refers in his introduction to the discovery of traces of secondary growth in Ophioglossum, and not to that of Isoëtes, a plant much more nearly related, as we now believe, to the Lepidodendraceæ, and the structure of which had been so thoroughly investigated by Hofmeister. Williamson, it is true, refers to the secondary growth in the stem of Isoëtes in his memoir on Stigmaria, but compares it with the periderm-forming cambium of that plant, and does not therefore recognise any agreement in the secondary growth of these two plants.

Adopting Von Mohl's interpretation of the root-bearing base of the Isoëtes plant as a 'caudex descendens,' Williamson instituted a morphological comparison between the latter and the branching Stigmaria, and came to the conclusion that they were homologous structures, a view which, as we heard at Sheffield, is supported by Dr. Lang on the strength of a re-examination of the anatomy of the stock of Isoëtes. If we do not accept Williamson's interpretation of the Stigmarian axis as a downward prolongation of caulome nature, the question remains open whether this underground structure represented a leafless modification of a normal leaf-bearing axis such as is known in the leafless rhizoms of Neottia and other saprophytic plants, or whether the Stigmarian axes were morphological entities of peculiar character. Grand' Eury, in comparing them with the rhizoms of Psilotum, accepted the former alternative and, apart from morphological considerations, was led to this view by the fact that he had observed aerial stems arising in many instances, as buds on the horizontal branches of Stigmaria. Confirmation of this mode of growth is still required, but it is quite conceivable that there may have been a mode of vegetative reproduction in the Stigmariæ analogous with that of Ophioglossum.[1]

The alternative interpretation of the Stigmarian axes as special morphological entities has received weighty support from Scott and Bower, who consider them

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[1] It is of interest in this connection to note that Potonié has recently put forward the suggestion that many of these vertical outgrowths from the more or less horizontal Stigmarian axes, some of which, as figured and described by Goldenberg, taper off rapidly to a point, without any trace of ramification, may be comparable with the conical 'knees' of Taxodium, and represent woody pneumatophores so common in the Swamp Cypress and other swamp-inhabiting trees.

comparable to the rhizophores of Selaginella, which, as is well known, may either be root-bearers, or under certain circumstances become transformed into leafy shoots. This peculiarity has led Goebel to regard them as special members, somewhat intermediate between stems and roots. But though they might therefore be regarded as of a primitive nature, the rhizophores of the Selaginellaceæ seem such specialised structures that I incline to agree with Bower that, as far as their correspondence to Selaginella is concerned, the Stigmarian axes would agree most closely with the basal knot formed on the hypocotyl of *Selaginella spinulosa.* Seeing, however, that the nearest living representative of the Lepidodendraceæ is in all probability Isoëtes, which Bower has aptly summarised as like 'a partially differentiated Lepidostrobus seated upon a Lepidodendroid base,' we must inevitably consider the root-bearing base of Isoëtes as homologous with the branching axes of Stigmaria, whatever their morphological nature may have been, and perhaps we shall be on the safest ground if we consider them both as different expressions of the continued growth of the lower region of the plant, which appears to have been a primary feature in the morphology of both these members of the Lycopodiales.

The somewhat considerable difference in external appearance between the homologous organs of these two plants may be considered bridged over by the somewhat reduced axes of Stigmariopsis and by the still more contracted base of the Mesozoic Pleuromoia, which, in spite of its very different fructification, we may unhesitatingly compare with Isoëtes as far as its root-bearing axis is concerned.

I was inclined at one time to seek an analogy for the Stigmarian axis in that interesting primitive structure, the protocorm of Phylloglossum, and of embryo Lycopods; but I now consider that the resemblances are largely superficial, and do not rest upon any satisfactory anatomical correspondence.

One of the features which has caused some divergence of opinion in the past as to the morphology of the Stigmarian axis has been the definite quincuncial arrangement and the apparent exogenous origin of the roots borne on these underground organs. Schimper, indeed, considered these two features so characteristic of foliar organs that he suggested that these so-called 'appendices' might possibly be metamorphosed leaves. Not quite satisfied with this view, Renault endeavoured to establish the existence of two types of lateral organs on the Stigmarian axis, true roots with a triarch arrangement of wood and root-like leaves of monarch type. Williamson, however, clearly showed that the apparent triarch arrangement was really due to the presence at two angles of the metaxylem of the first tracheids of secondary wood, and reasserted the existence of only one type of appendicular organs, agreeing so closely, both in structure and in their orientation to the axis, on which they were borne, with the roots of Isoëtes that it would be impossible to deny the root nature of the Stigmarian 'appendices' without applying the same treatment to the roots of Isoëtes.

Still, so distinguished a palæobotanist as Solms Laubach, after a careful weighing of all the available evidence, continued to uphold Schimper's view of the foliar nature of these outgrowths, both in his Palæophytologie and in his memoir on Stigmariopsis, in which he stated that he was in complete agreement with Grand' Eury's conclusion: 'Que ces organes sont indistinctement des rhizomes et que les Sigillaires n'avaient pas de racines réelles, ainsi que Psilotum.' Indeed, in reviewing the account I gave of the occurrence of a special system of spiral tracheids in the outer cortex of the Stigmarian rootlets, Count Solms drew attention to their similarity to the transfusion tissue of Lepidodendroid leaves, and asserted that we have here a further indication of the former foliar nature of these rootlets. Personally, I still adhere to the belief, expressed at the time, that these peripheral cortical tracheids represent a special development required by a plant with an aquatic monarch root of the Isoëtes type and a large development of aerial evaporating surface. The fact that the lateral outgrowths from the Stigmarian axis have been generally considered to be exogenous is not a valid argument against their root nature, as the same origin is ascribed to the roots of Phylloglossum and to those produced on the rhizophores of Selaginella. Probably, indeed, as Bower points out in his masterly exposition of the 'Origin of a Land Flora,' in dealing with the Lycopodiales, 'the root in its inception

would, like the stem of these plants, be exogenous.' According to the 'recapitulation theory,' indeed, the exogenous formation of the roots in the embryo of certain Lycopods, as well as of the first root of Isoëtes and the first root of the Filicales, might be regarded as the retention of a more primitive character in these particular organs. The roots of Stigmaria, even if exogenous, might therefore merely represent a more ancestral stage. This difference between the roots of Isoëtes and the rootlets of Stigmaria may, however, be more apparent than real, for my colleague, Dr. Lang, has drawn my attention to the fact that there appear to be in Stigmaria remnants of a small-celled tissue on the outside of what has generally been taken to be the superficial layer of the Stigmarian axis, and a careful investigation of this point inclines me to agree with him that very probably the Stigmarian rootlets were actually formed like those of Isoëtes, somewhat below the surface layer, which, after the emergence of the rootlets, became partially disorganised. Should this surmise prove correct, when apices of Stigmaria showing structure come to light, the last real difference between the rootlets of Isoëtes and the rootlets of Stigmaria will have disappeared, and the view for which Professor Williamson so strongly contended will be finally established.

While a careful comparison of Isoëtes with the extinct Lycopodiaceous plants may be taken finally to settle its systematic position, the Psilotaceæ have been somewhat disturbed by such comparisons. Placed formerly without much hesitation in the phylum Lycopodiales, certain features in their organisation, such as the dichotomy of their sporophylls, and the structure of their fructification generally have suggested affinity with that interesting group of extinct plants, the Sphenophyllales. Their actual inclusion in this group by Thomas and by Bower may seem, perhaps, somewhat hazardous, considering the differences existing between the Psilotaceæ and Sphenophyllum; and the more cautious attitude of Seward, in setting up a separate group for these forms, seems on the whole more satisfactory than forcing these aberrant relatives of the Lycopods into the somewhat Procrustean bed of Sphenophyllales, which necessitates the minimising of such important differences as the dichotomous branching of the axis and the alternate arrangement of their leaves, though the latter character allows, it is true, of some bridging over. But, even adopting this more cautious attitude, the study of the Sphenophyllales has been of great help in coming to a clearer understanding of certan morphological peculiarities of the Psilotaceæ, quite apart from the flood of light which this synthetic group of Sphenophyllales has thrown upon the relationship of the Lycopodiales to the Equisetales.

More far-reaching in its bearing on the relationships of existing plants has been the study of those interesting fern-like plants, which seem to show in their vegetative organs a structure possessing both fern-like and Cycadean affinities. Full of interest as these so-called Cycadofilices were in their vegetative organisation, they were destined to rivet on themselves the attention of all botanists by the discovery of their fructifications. No chapter in the recent history of Palæobotany is more thrilling than the discovery, by the patient and thorough researches of Professor Oliver, of the connection between Lyginodendron and the well-known palæozoic seed, Lagenostoma. With Dr. Scott as sponsor, this new and startling revelation met with ready acceptance, and, thanks to the indefatigable energies of Palæobotanists, no fossil fern seemed at one time safe from possible inclusion among the Pteridospermæ.

The infectious enthusiasm with which the discovery of the seed-bearing habit of the Lyginodendreæ and the Medulloseæ was greeted carried all before it, and we in England particularly have perhaps not looked carefully enough into the foundations upon which rested the theory that these groups form the 'missing links' between the Ferns and Cycads. A criticism against the wholesale acceptance of this view has been put forward by Professor Chodat,[2] of Geneva, that distinguished and versatile botanist whom we have on several occasions had the pleasure of welcoming in our midst. Couched throughout in friendly and courteous language, and full of admiration for the work of those who were concerned in the establishment of the group of Cycadofilices, now termed

[2] Chodat, R.: 'Les Ptéropsides des temps paléozoïques,' *Archives des Sciences physiques et naturelles*, Genève, tome xxvi., 1908.

Pteridospermæ, Professor Chodat suggests that English palæobotanists have not sufficiently appreciated the work of Bertrand and Corneille[3] on the fibro-vascular system of existing ferns, and have not revised, in the light of the researches of these French investigators, the interpretation given to the arrangement of the primary vascular tissues of Lyginodendron. In Chodat's opinion the structure of the primary groups of wood found in the stem and in the double leaf-trace of this plant is not directly comparable with the arrangement found in the petiole of existing Cycads. In the latter the bulk of the metaxylem is centripetal, while we have in addition a varying amount of small-celled centrifugal wood towards the outside of the protoxylem, and though separated from it by a group of parenchymatous cells, the bundle may be conveniently described as mesarch. In Lyginodendron, and the same applies to Heterangium, the primary bundles of the stem appear at first sight to be mesarch too, but in Chodat's opinion, if I understand him correctly, the metaxylem is exclusively centrifugal in its development, but, widening out and bending inwards again, in form of the Greek letter 'ω,' the two extremities of the metaxylem are united on the inside of the protoxylem, forming an arrangement described by Bertrand and Corneille in the case of several fern petioles under the name of 'un divergeant fermé.'

Several details of structure, such as the type of pitting of the metaxylem elements and the separation of the protoxylem from the adaxial elements of metaxylem by parenchymatous cells, confirm Chodat in his view that the primary bundles of Lyginodendron are not really mesarch, and that the stem of Lyginodendron is essentially Filicinean in nature. Chodat cites other characters, such as the presence of sclerised elements in the pith, and the absence of mucilage ducts, in support of his view of the purely filicinean affinities of the Lyginodendreæ. The presence of secondary thickening in Lyginodendron, he regards not as indicative of Cycadean affinity, but merely as another instance of secondary growth in an extinct Cryptogam, taking up very much the position of Williamson in his earlier controversy with French botanists with regard to the secondary thickening of Calamites and Lepidodendreæ. Chodat is also at variance with Kidston and Miss Benson as to the nature of the microspores borne on the fronds of Lyginodendron or Lyginopteris, as he prefers to call this plant. He certainly figures some very fern-like sporangia, attached to the fronds of Lyginodendron, but anyone who has worked with the very fragmentary and somewhat disorganised material contained in our nodules knows how difficult it is to be absolutely certain of structural continuity. Nevertheless a re-investigation of the whole question of the microsporangia of Lyginodendron seems to me clearly called for by the publication of Chodat's figures.

As regards the seed-bearing habit of Lyginodendron, Chodat adopts wholeheartedly Oliver's correlation of Lagenostoma with the fronds of Lyginodendron, but would regard the seed, apparently devoid of endosperm at the time of pollination, as a somewhat specialised macrosporic development, of more complex structure, but analogous in its nature to the seed-like organ exhibited by Lepidocarpon in another phylum of the Pteridophyta. 'In any case,' he concludes, 'the origin and the biology of this kind of seed must have been very different from those of the seeds of the Gymnosperms.'

This contention, based mainly on the tardy development of the endosperm in Lagenostoma, is the least weighty part of Chodat's criticism, for it has never been asserted that the seeds were identical with those of existing Cycads. We know that the seed-habit was adopted by various groups of Vascular Cryptogams, and it is revealed in fossil plants in various stages of evolution, so that it may be readily presented to us at a special stage of its evolution in Lyginodendron. Moreover, we must remember that in so highly organised a Gymnosperm as Pinus, the macrospore itself is not fully developed at the time of pollination. Though not suggesting this as a primitive feature in the case of the pine, we can well imagine how, by a gradual process of 'anticipation,' the prothallus might become established before pollination in any group of primitive seed-bearing plants. There are other more specialised rather than primitive features in the complex structure of Lagenostoma which might with much more reason

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[3] Bertrand, C. E., and Corneille, F.: 'Etude sur quelques caractéristiques de la structure des filicinées actuelles,' *Travaux et mémoires de l'Université de Lille*, 1902.

be invoked, to show that the seed of Lyginodendron does not form a step in the series of forms leading to the Cycadean ovule.

But leaving this point out of consideration, Chodat brings forward some strong reasons for his conclusions that the Lyginodendreæ were plants possessing stems of purely fern-like structure, increasing in thickness by means of a cambium, that their foliage was of filicinean structure, but provided with two kinds of sporangia, microsporangia similar to those of Leptosporangiate ferns, and macrosporangia of specialised type, containing a single macrospore. This group, therefore, Chodat regards as a highly specialised group of ferns, which, he considers, shows no particular connection with the Cycads, and which may have formed the end in a series of highly differentiated members of the Filicineæ.

Of the Medullosæ, on the other hand, Chodat takes a very different view. Both in the structure of their primary and secondary growth, as well as in their polystely, he sees close affinity of these forms to the Cycads, borne out by smaller secondary features, such as the presence of mucilage ducts, and the simple form of pollen-chamber. Chodat considers the agreement of the Medullosæ with the Cycadaceæ to be so close that he regards them as Protocycadeæ, the fern-like habit being restricted to the position of the sporangia on the vegetative fronds. Medullosa, therefore, would be only one link in the chain connecting the Cycads with the Filicales, and a link very near the Cycadean end of that chain. Other forms more closely connected with the Filicinean phylum are still to be sought.

In bringing Professor Chodat's views to your notice, I do not wish to urge their acceptance, but his criticism seems to me sufficiently weighty to demand a careful reconsideration of the structure and affinities of the Lyginodendreæ, which, whatever may be their ultimate position in our scheme of classification, will continue in the future, as they have done in the past, to command the attention of all botanists interested in the evolution of plant life.

If the wholeheartedness with which we in England received the theory of the Cycadean affinity of Lyginodendron has laid us open to friendly criticism, I am afraid some of us may be accused of exceeding the speed-limit in our rapid acceptance of the Cycadoidean ancestry of the Angiosperms. Ever since Wieland put forth the suggestion in his elaborate monograph of the 'American Fossil Cycads' that 'further reduction and specialisation of parts in some such generalised type, like the bisporangiate strobilus of Cycadoidea, could result in a bisexual angiospermous flower,' speculation as to the steps by which the evolution might have been brought about has been rife, and Hallier in Germany and Arber and Parkin in England have put forward definite schemes giving probable lines of descent. Arber and Parkin in their criticism and detailed suggestions connect phylogenetically with the Bennettitales, the Ranales, as primitive Angiosperms, and displace from this position the Amentales and Piperales, which were regarded by Engler as probably more closely related to the Pro-angiosperms. Of course, the resemblance between the amphisporangiate, or, as I should prefer to call it, the heterosporangiate 'strobilus' of Cycadoidea, and the flower, say, of Magnolia is very striking, and the knowledge we have gained of the structure and organisation of the Bennettitales certainly invites the belief in a possible descent of the Angiosperms from this branch of the great Cycadean plexus; but the ease with which the flower of the Ranales can in some respects be fitted on to the 'flower' of Cycadoidea raises suspicion. Critics of the Arber-Parkin hypothesis may possibly incline to the view that 'truth is often stranger than fiction,' and that the real descent of the Angiosperms may have been much less direct than that put forward in these recent hypotheses. The particular view of the morphology of the intraseminal scales and seed pedicles adopted by Arber and Parkin is, as they admit, not the only interpretation that can be put upon these structures, and the views on this point will probably remain as various as are those of the female cone of Pinus. Even if we regard the ovulate portion of the Cycadoidean 'flower' as a gynæcium, and not as an inflorescence, we are bound to admit, as do Arber and Parkin, that it is highly modified from the pro-anthostrobilus type with a series of carpels bearing marginal ovules. Cycadoidea was evidently a highly specialised form, and may well have been the last stage in a series of extinct plants.

Arber's very sharp separation of mono- and amphisporangiate Pteridosperms

does not seem to me quite justified. Amphisporangiate forms may have been preserved, or may have arisen anew in various groups of Pteridosperms or in their descendants. Heterospory, we know, originated independently in at least three of the great phyla of vascular Cryptogams, and originally, no doubt, the same strobilus contained both macro- and micro-sporangia, as was the case in Calamostachys Casheana, in the strobili of most Lepidodendraceæ, and as is still the case in the strobili of Selaginella and in Isoëtes. Even in the existing heterosporous Filicineæ, micro- and macro-spores are found on the same leaf, and on the same sorus; and though in the higher Cryptogamia and the lower Phanerogamia there may have been a tendency to an iso-sporangiate condition, yet, as the two kinds of spores are obviously homologous in origin, nothing is more natural than an occasional reversion to a heterosporangiate fructification. Thus in the group of Gymnosperms we have many instances of the occurrence of so-called androgynous cones. In 1891, at the meeting of the British Association in Leeds, I described such amphisporangiate cones which occurred regularly on a *Pinus Thunbergii* in the Royal Gardens of Kew, and only this spring I was able to gather several hermaphrodite cones of *Larix Europea.* They have, of course, been observed and described by many authors for a variety of Gymnosperms. What more likely than that many extinct Gymnosperms may have developed heterosporangiate fructifications? It is not necessary, therefore, to fix on one group of ancestors for the origin of all existing Angiosperms. Indeed, the great variety of forms, both of vegetative and reproductive organs, which we meet with in the Angiosperms, not only to-day but even in the Cretaceous period, in which they first made their appearance, warrants, I think, the belief in a polyphyletic origin of this highest order of plants. It is no doubt true, as Wieland points out, 'that the plexus to which Cycadoidea belonged, as is the case in every highly organised plant type, presented members of infinite variety,' and, indeed, so far as the vegetative organisation goes, we know already, through the labours of Nathorst, of such a remarkable form as *Wielandiella angustifolia,* while Wieland has shown us a further type in his Mexican Williamsonia. Nevertheless, these diverse forms all agree in the structure of their gynæcium, the particular organ which is not so easy to bring into line with that of the Angiosperms.

I am quite alive to, though somewhat sceptical of, the possibility of a direct descent of the Ranales from the Cycadoideæ, but my hesitation in accepting Arber and Parkin's view of the ancestry of the Angiosperms is enhanced by the consideration that it seems almost more difficult to derive some of the apparently primitive Angiosperms from the Ranales, than the latter from Cycadoidea. Indeed, this common origin of Angiosperms from the Ranalian plexus will, I feel sure, prove the stumbling-block to any general acceptance of the Arber-Parkin theory. It is easy enough to assume that all Angiosperms with the unisexual flowers have been derived by degeneration or specialisation, from forms with hermaphrodite flowers of the primitive Ranalian type, but unfortunately some of these degenerate forms possess certain characters which appear to me to be undoubtedly primitive.

It is difficult for those who accept Bower's view of the gradual sterilisation of sporogenous tissue not to regard the many-celled archesporium in the ovules of Casuarina and of the Amentales as a primitive character, and though, as Coulter and Chamberlain point out, this feature is manifested by several members of the Ranunculaceæ and Rosaceæ, as well as by a few isolated Gamopetalæ, its very widespread occurrence in the Amentales seems to indicate its more general retention in this group of plants, and does not agree readily with the theory that these unisexual Orders are highly specialised plants, with much reduced flowers. The possession of a multicellular archesporium is, however, not the only primitive character exhibited by some of the unisexual orders of the Archichlamydeæ. Miss Kershaw[4] has shown, in her investigation of the structure and development of the ovule of Myrica, that in this genus, which possesses a single erect ovule, the integument is entirely free from the nucellus, and is provided with well-developed vascular bundles, in both of which features it resembles very closely the palæozoic seed Trigonocarpus. The same features were shown, moreover, by Dr. Benson[5] and Miss Welsford to occur in the

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[4] *Annals of Botany,* vol. xxiii., 1909.

[5] *Ibid.*

ovules of Juglans regia, and in a few allied genera, such as Morus and Urtica. Also in a large number of Amentales with anatropous ovules (Quercus, Corylus, Castanea, &c.), Miss Kershaw has demonstrated the occurrence of a well-developed integumentary vascular supply. No doubt a further search may reveal the occurrence of this feature in some other dicotyledonous ovules, but in the meantime it seems difficult to believe that such a primitive vascular system, which the Amentales share with the older Gymnosperms, would have been retained in the catkin-bearing group, if it had undergone far-reaching floral differentiation, while it had disappeared from the plants which in other respects remained primitive. It would be still more difficult to imagine that it had arisen in the Amentales subsequently to their specialisation.

There are other structural characters and general morphological considerations, which I have not time to deal with, which underlie the belief in the primitiveness of the Amentales and some allied cohorts, and I trust they will be set forth in detail by a better systematist than I can claim to be. My object in bringing the matter forward at all is to point out some of the difficulties which prevent me from accepting a monophyletic origin of the Dicotyledons through the Ranalian plexus.

One of these difficulties lies in the relationship of the Gnetales to the Dicotyledons. Arber and Parkin have recently made the attempt to gain a clearer insight into the affinities of this somewhat puzzling group by applying to it the 'strobilus theory[6] of Angiospermous descent.' The peculiar structure of the flowers of Welwitschia lends itself particularly well to a comparison with those of Cycadoidea, and a good case can no doubt be made out for a hemiangiospermous ancestry of this member of the Gnetaceæ, and by reduction the other members, in many respects simpler, might be derived from a similar ancestor, though probably, as far as Ephedra and Gnetum are concerned, an equally good, if not better, comparison, might be made with Cordaites. But even supposing we admit the possibility of a derivation of the Gnetales from an amphisporangiate Pteridosperm, I think the Amentales merit quite as much as the Gnetales to be considered as having taken their origin separately from the Hemiangiospermæ, and not from the Ranalian plexus. I find this view has been put forward also by Lignier[7] in his attempt to reconstruct the phylogenetic history of the Angiosperms, and I feel strongly that such a polyphyletic descent, whether from the more specialised anthostrobilate Pteridospermæ or from several groups of a more primitive Cycado-Cordaitean plexus, is more in accordance with the early differentiation of the Cretaceous Angiosperms, and with the essential differences existing now in the orders grouped together as Archichlamydeæ.

Attempts at reconstructing the phylogeny of the Angiosperms are bound to be at the present time largely speculative, but we may possibly be on the threshold of the discovery of more certain records of the past history of the higher Spermaphyta, since Dr. Marie Stopes has commenced to publish her investigations of the cretaceous fossil plants collected in Japan, and Professor Jeffrey has been fortunate enough to discover cretaceous plant-remains showing structure in America. The former have already provided us with details of an interesting Angiospermic flower, and if the latter have so far only yielded Gymnosperms, we may at all events learn something of the primitive forms of these plants, the origin of which is still as problematical as is that of the Angiosperms.

I trust that the criticisms I have made of the theory put forward by Messrs. Arber and Parkin will not be taken as a want of appreciation on my part of the service they have done in formulating a working hypothesis, but merely as an expression of my desire to walk circumspectly in the very alluring paths by which they have sought to explore the primæval forest, and not to emulate those rapid but hazardous flights which have become so fashionable of late.

While the description of new and often intermediate forms of vegetation

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[6] Arber, E. A. N., and Parkin, J.: 'Studies on the Evolution of Angiosperms,' 'The Relationship of the Angiosperms to the Gnetales,' *Annals of Botany*, vol. xxii., 1908.

[7] Lignier, O.: 'Essai sur l'Evolution morphologique du Règne vegetal,' *Bull. de la Soc. Linnéenne de Normandie*, 6 sér., 3 vol., 1909, reimprimé février 1911.

has aroused such widespread and general interest in Palæobotany, other and more special aspects of the subject have not been without their devotees, and have proved of considerable importance. Morphological anatomy has gained many new points of view, and our knowledge of the evolution of the stele owes much to a careful comparison of recent and fossil forms, even when these investigations have produced conflicting interpretations and divergent views.

Another promising line of Palæobotanical research lies in the direction of investigations of the plant tissues from the physiological and biological points of view. Happily, the vegetable cell-wall is of much greater toughness than that of animal cells, and in consequence the petrified plant-remains found in the calcareous nodules are often so excellently preserved that we can not only study the lignified and corky tissues but also the more delicate parenchymatous cells. Even root-tips, endosperm, and germinating fern-spores are often so little altered by fossilisation that their cells can be as easily studied as if the sections had been cut from fresh material. It is this excellence of preservation which has enabled us to gain so complete a knowledge of the anatomy of palæozoic plants, and since the detailed structure of plant organs is often an index of the physical conditions under which the plants grew, we are able to form some opinion as to the habitat of the coal-measure plants. Though a beginning has already been made in this direction by various authors, we have as yet only touched the fringe of the subject, and, as Scott points out in the concluding paragraph of his admirable 'Studies,' the biology and ecology of fossil plants offer a wide and promising field of research. Such studies are all the more promising, as we now have material from such widely separated localities as the Lancashire coalfield, Westphalia, Moravia, and the Donetz Basin in Russia.

Now that it has been definitely shown by Stopes and Watson that the remains of plants are sometimes continuous through adjacent coal-balls, we may safely accept their conclusion that these calcareous concretions were in the main formed *in situ,* and that the plant-remains they contain represent samples of the vegetable débris of which the coal-seam consists. We have in these petrifactions, therefore, an epitome, more or less fragmentary, of the vegetation existing in palæozoic times on the area occupied by the coal seam, and the Stigmarian roots in the underclay, as well as other considerations, lead us to believe that the seam more frequently represents the remains of the coal-measure forest carbonised *in situ.* While this seems to be the more usual formation of coal-seams, it is obvious from the microscopic investigations of coal made by Bertrand, and as has recently been so clearly set forth by Arber in his 'Manual on the Natural History of Coal,' that in the case of Bogheads and Cannels the seam represents metamorphosed sapropelic deposits of lacustrine origin. In other cases again, considerations of the nature of the coal and the adjacent rocks may incline us to the belief that some, at any rate, of the deposits of coal may be due to material drifted into large lake-basins by river agency.

Broadly speaking, however, and particularly when dealing with the seams from which most of our petrified plant-remains have been collected, we may consider the coal as the accumulated material of palæozoic forests metamorphosed *in situ.* What, then, were the physical and climatic conditions of these primæval forests? The prevalence of wide air-spaces in the cortical tissues of young Calamitean roots, as indeed their earlier name Myriophylloides indicates, leads us to believe that, as in the case of many of their existing relatives, they were rooted under water or in waterlogged soil. We gather the same from the structure of Stigmaria, while the narrow xerophytic character of the leaves at any rate of the tree-like Calamites and Lepidodendra closely resembles the modifications met with in our marsh plants. It has been suggested by several authors that the xerephytic character of the foliage of many of our coal-measure plants may be due to the fact that they inhabited a salt marsh. A closer examination of the foliage, however, of such plants as Lepidodendron and Sigillaria does not reveal the characteristic succulency associated with the foliage of most Halophytes, and in view of the absence of such water-storing parenchyma, the well-developed transfusion-cells of the Lepidodendreæ can only be taken to be a xerophytic modification such as is met with in recent Conifers.

The specialisation of the tissues indeed is only such as is quite in keeping

with the xerophytic nature of marsh plants. Moreover, the particular group of Equisetales are quite typical of fresh water, and we should expect that if their ancestors had been Halophytes, some at any rate at the present day would have retained this mode of life. Nor have we at the present time any halophytic Lycopodiales, while Isoëtes, the nearest relative to the Lepidodendra, is an aquatic or sub-aquatic form associated with fresh water.

Among the Filicales, *Acrostichum aureum* seems to be the only halophytic form, inhabiting as it does the swamps of the Ceylon littoral,[1] and though, as Miss Thomas has pointed out, its root structure is in close agreement with that of many palæozoic plants, its frond shows considerable deviation from that of Lyginodendron or Medullosa, both of which plants, as Pteridosperms, are on a higher plane of evolution, and might therefore be expected to show a more highly differentiated type of leaf. But on the contrary these coal-measure plants show a more typically Filicinean character, both as regards the finely dissected lamina, and also in the more delicate texture of the foliage compared with the specialised organisation of the frond of *Acrostichum aureum* described by Miss Thomas.

Nor is it necessary to call to aid the salinity of the marsh to explain the excellent preservation of the tissues of the plant-remains in the so-called coal-balls, in view of the well-known power of humic compounds to retard the decay of vegetable tissues. In addition to those arguments, I might draw attention to the presence of certain fungi among the petrified débris, as more likely to be found in fresh water than in marine conditions. Peronosporites, so common in the decaying Lepidodendroid wood, and the Urophlyctis-like parasite of Stigmarian rootlets, seem to me to support the fresh-water nature of the swamp; just as the occurrence of the mycorhiza, described by Osborn, in the roots of Cordaites seems to indicate the presence of a peaty substratum for the growth of that plant. Potonié also refers to the occasional occurrence of Myriapoda and fresh-water shells as indicative of the fresh-water origin of at least many of the coal deposits, and a common feature of the petrified remains of coal-measure plants is the occurrence of the excrements of some wood-boring larvæ in the passages tunnelled by these palæozoic organisms through the wood of various stems.

A strong argument in favour of the brackish nature of these swamps would be supplied by the definite identification of Traquairia or Sporocarpon as Radiolaria, though we must remember that certain marine Cœlenterata find their way up into the Norfolk Broads, and fresh-water Medusæ are by no means unknown in different parts of the tropics. Of course, if the coal-measure swamps were estuarine or originated in fresh-water lagoons near the sea, they may have been liable from time to time to invasions of salt water, sufficient to account for the presence of occasional marine animals, but without constituting a halophytic plant association.

Potonié, who has made so close a study of the formation of coal, and who supports the theory of its fresh-water origin, considered for a long time the comparison between the coal-measure swamp and the cypress swamps of North America, as the nearest but at the same time a somewhat remote analogy, more particularly as he believed that the nature of the coal-measure vegetation required a tropical and also a moister climate than obtains in the Southern States of North America. Though, in view of the great development of Pteridophytic vegetation in countries like New Zealand, I think Potonié possibly exaggerates the temperature factor, he is probably right in assuming a fairly warm climate for the coal-measure forest. The difficulty, so far, has been to account for the great thickness of humic or peaty deposits which must have accumulated for the formation of our coal-seams, in view of the fact that extensive peat formation is generally associated with a low temperature. In the Tropics, peat may be deposited at high altitudes, where there is low temperature and high rainfall, but it is generally supposed that the rate of decomposition of vegetable remains is so active that lowland peat-formation was out of the question. Dr. Koorders, however, has observed a peat-producing forest in the extensive plain on the east side of Sumatra, about a hundred miles from the coast. This swamp-forest has been recently re-explored at the instance of Professor

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[1] Tansley, A. G., and Fritsch: 'The Flora of the Ceylon Littoral,' *New Phytologist*, vol. iv., 1905.

Potonié, and he finds it to agree closely with the vegetative peculiarities which he considers must have been presented by the vegetation of the coal-measure forest. A typical 'Sumpflachmoor,' this highly interesting tropical swamp has produced a deposit of peat amounting in some places to thirty feet in thickness. The peat itself consists mainly of the remains of the Angiospermic vegetation of which the forest is made up, including pollen-grains, and occasional fungal filaments; the preservative power, which has enabled this accumulation of débris to take place, being due to the peaty water which is seen above the roots of the bulk of the vegetation. The latter consists mainly of dicotyledonous trees belonging to various Natural Orders, and they mostly show such special adaptations as breathing roots (pneumatophores) and often buttress roots. With the exception of a tree-fern, Pteridophyta, Liverworts and Mosses, and, indeed, all herbaceous vegetation, are poorly represented in this swamp, though high up in the branches of the trees there are a fair number of epiphytes, and at the edge of the swamp-forest lianes, belonging particularly to the palms, play an important part in the vegetation. The water, partly on account of its peaty nature, partly owing to the intense shade, is almost devoid of algæ, and none of these organisms were found in the peat itself. The interesting account given by Potonié of this tropical peat-formation is very suggestive when certain features, as, for example, the absence or relative paucity of certain of the lower groups of plants, such as algæ and Bryophyta, in the peat, are compared with the plant-remains in some of our coal-seams. Replacing the now dominant Angiosperms by their Pteridophytic representatives in palæozoic times, we have a very close parallel in the two formations.

Another interesting question arises when we consider the great variety of types of vegetation met with among the plant-remains of the coal-seams. For in addition to the limnophilous Calamites and Lepidodendraceæ mentioned above, the coal-balls abound with the remains of representatives of the Filicales, the Pteridospermæ, and the Cordaitaceæ. Were these also members of this swamp vegetation, or have their remains been carried by wind or water from surrounding areas? With regard to some plant-remains, namely, those found exclusively in the roof nodules, the latter was undoubtedly the case; for we have ample evidence, both in their preservation and their mode of occurrence, that they have drifted into the region of the coal-measure swamp after its submergence below the sea. This would apply to such plants as *Tubicaulis Sutcliffii* (Stopes), *Sutcliffia insignis* (Scott), *Cycadoxylon robustum* and *Poroxylon Sutcliffii*, and other forms, the remains of which have so far not been observed in the coal-seam itself. These plants represent a vegetation of non-aquatic type, and may be taken to have grown on the land areas surrounding the palæozoic swamps. But, on the other hand, we have remains of many non-aquatic plants in the coal-seam itself, closely associated with fragments of typical marsh-plants. How can their juxtaposition be explained?

The advance of our knowledge of ecology points, I think, to a solution of this difficulty. No feature of this fascinating study, which has of late gained so prominent a place in botanical investigation, is more interesting than to trace out the succession of plant associations within the same area, noting the ever-changing conditions which the development of each association brings about. If we follow with Schroeter the gradual development of a lacustrine vegetation from the reed-swamp through the marsh (or Flachmoor) to a peat-moor (Hochmoor), we see how one plant association makes place in its turn for another. May not the mixture of various types of vegetation which we meet with in the petrifactions of our coal-seam represent the transition from the open Calamitean or Lepidodendroid swamp to a fen or marsh with plentiful peat-formation, due to the gradual filling up of the stagnant water with plant-remains? Thus in places at any rate a transition from aquatic to more terrestrial types of vegetation would take place, while the tree-like forms rooted in the deeper water would continue to flourish. The coal-measure swamp in this stage would differ from the tropical swamp of Kooders by a more abundant undergrowth of herbaceous and climbing plants, rooted in damp humus and passing off gradually into drier peat. Such an undergrowth of Cryptogamic types, mainly Filicinean or Pteridospermic, would have admirable conditions for luxuriant development, apart from the provision of a suitable substratum for its roots, owing to the narrow

xerophytic nature of the foliage on the canopy of the trees under which it grew.

Here, too, we see the explanation of the striking difference between the microphyllous and arborescent Calamites and Lepidodendraceæ, and the large ombrophile foliage of the Filicineæ and Pteridosperms, which spread out their shade-leaves under the cover of marsh xerophytes, in exactly the same way as Professor Yapp has so admirably depicted for recent plants in his account of the 'Stratification in the Vegetation of a Marsh.'

The development of a mesophytic vegetation in the shelter of the marsh xerophytes makes it unnecessary to postulate an obscuration of the intense sunlight by vapours, as was done by Unger and Saporta for the Carboniferous period. The assumption of a variety of conditions of plant life within the same area helps materially to clear up the difficulties presented by the somewhat incongruous occurrences met with in the petrified plant-remains. The presence of fragments of Cordaites, mixed with those of Calamites and Lepidodendra, in the coal-balls cannot always be explained either by a drift theory or by conceiving the fragments to be wind-borne; but, given an area of retrogressive peat above the ordinary water-level, and even so xerophytic a plant as Cordaites might well establish itself there, its mycorhiza containing roots being well adapted for growth in drier peat. The curious occurrence of more or less concentric rings in the secondary wood of the stem and roots of Cordaites may represent a response, probably not to annual variations of climate but to abnormal periods of drought, which would affect the upper-peat layers, but not the water-logged soil in which were rooted the Calamites and Lepidodendra.

If, as I suspect, we had in the peat deposit of the coal-seam a succession of associations, we ought to find its growth and history recorded by the sequence of the plant-remains, very much as Mr. Lewis has discovered with such signal success in our Scottish peat-bogs. That some differences occur in the plant-remains building up a seam can be noted by a microscopic examination of the coal itself, in which, as Mr. Lomax tells me, the spores of Lepidodendra occur in definite bands. But no systematic attempt has as yet been made to investigate from this point of view the seams charged with petrified plant débris. Before the Shore pit, which was reopened last summer through the renewed generosity of Mr. Sutcliffe, was finally closed down, I obtained two series of nodules, ranging from the floor to the roof of the seam, and have had these cut for detailed examination. I should not, however, like to make any generalisation from these isolated series, but intend, during the coming winter, to investigate in the same manner further series taken from large blocks of nodules, which have been removed bodily so as to retain the position they occupied in the seam. Though at present the data are only fragmentary, there seems to be some indication that the plant-remains are not without some relation to their position in the seam. Of course, Stigmarian rootlets are ubiquitous, and in the nodules of the lower part of the seam predominant, but other plant-remains appear to be more frequently found at one level of the seam than another. The problem, however, is very involved, and it has become apparent that it is as important to study the fine débris in which the larger fragments are embedded as the distribution of these latter. Moreover, attention must be paid to the stage of decomposition presented by the particles forming the matrix of the nodule, as this varies in the lower and upper parts of a seam, very much as in a peat-bed we can distinguish the lighter coloured fibrous peat from the darker layers at the base of a peat-cutting. Mr. Lomax, who has so unique an experience of these coal-balls, informs me that he can tell whether a nodule is from the top or bottom of the seam by the lighter or darker colour of the matrix. The importance of applying the methods which have been so successful in elucidating the history of modern peat-deposits to the investigation of the coal-seam will be clearly appreciated both by palæobotanists and ecologists, and this particular problem offers a striking illustration of the interdependence of various branches of botanical investigation. It is fortunate indeed that the two fields of work, Palæobotany and Plant Ecology, though they have been subjected to fairly intensive cultivation, have not become exclusively the domain of specialists. The strength and progress of modern Botany have been due to the close collaboration of workers engaged in different branches of botanical science, and the fact that

British ecologists have combined to attack a series of the problems from very diverse points of view leads one to hope that, with a continuance of that intimate co-operation which has characterised their work so far, and with the added stimulus of the friendly visit of our distinguished colleagues from abroad, considerable progress may be expected in the future in this branch of botanical study. Privileged as I have been to assist at the deliberations of the British ecologists, without as yet having taken any active part in their work, I feel myself at liberty to point with appreciation to the excellent beginning they have made of a botanical survey of Great Britain and Ireland, as well as to the more detailed investigations of special associations and formations, such as the woodlands, the moorlands, the fens, the broads, salt marshes, and shingle beaches. I am glad to think that our foreign visitors have been able to see those interesting types of vegetation under the guidance of those who have made a special study of these subjects.

The importance to ecologists of an up-to-date critical Flora was dwelt upon by my predecessor in this presidential chair, and this obvious need may be regarded as a further illustration of the inter-relationship of the various aspects of Botanical Science. Though it has been obvious to all that the swing of the pendulum has been for a long time away from pure systematic botany, I am convinced that the great development of plant ecology, of which we have many indications, will not merely lessen the momentum of the swinging pendulum, but will draw the latter back towards a renewed and critical study of the British flora. That a revival of interest in systematic botany will come through the labours of those who are engaged in survey work and other forms of ecological study, is foreshadowed by the fact that Dr. Moss has undertaken to edit a 'New British Flora,' which will, I believe, largely fulfil the objects put forward by Professor Trail in his Presidential Address. I trust, however, that in addition to the ecologists, those botanists who are interested in genetics will contribute their share towards the completion of our knowledge of critical species, varieties, and hybrids, all of which offer such intricate problems alike to the systematist and to the student of genetics.

De Vries prefaced his lectures on 'Species and Varieties, their Origin by Mutation,' by the pregnant sentence: 'The origin of species is an object of experimental investigation,' and this is equally true of the study of the real and presumptive hybrids of our British flora, which may be investigated either synthetically or, when fertile, also analytically, as in some cases their offspring show striking Mendelian segregation. Some good work has already been accomplished in this direction, but more remains to be done, and we have here an important and useful sphere of work for the energies of many skilled plant-breeders.

I would, therefore, like to plead for intimate collaboration between all botanists, hopeful that, as progress in the past has come through the labours of men of wide sympathies, so in the future, when studies are bound to become more specialised, there will be no narrowing of interests, but that the various problems which have to be solved will be attacked from all points of view, the morphological, the physiological, the ecological, and the systematic. Thus by united efforts and close co-operation of botanists of all schools and of all countries we shall gain the power to surmount the difficulties with which our science is still confronted.

The following Papers were read:—

1. *The Life-History of a Shingle Bank.*

By Professor F. W. Oliver, *F.R.S.*

This communication dealt with the conditions under which plants exist on accumulations of maritime shingle reaching above spring-tide limits. The localities studied include the following shingle-banks: Blakeney, Chesil, Hurst Castle, Calshot, Hamstead Dover (Isle of Wight), and Rye.

The first point to be emphasised is the mobility of most shingle banks, resulting in a landward creep of the bank as a whole. This lateral movement is promoted by two distinct but related processes. (1) By the direct action of storm waves which lifts the shingle over the crest and scatters it down

the landward slope. (2) By the percolation of sea-water at high tide, whereby shingle at the foot of the landward slope is dislodged by gushes of water, with the result that the bank is constantly undermined and shingle descends from above. (1) is of special importance in the case of low banks on exposed coasts, (2) where the crest of the bank stands high above tidal limits.

Banks in which these processes are operative offer conditions analogous to those obtaining on wandering sand dunes. Whilst some parts of a shingle bank are thus rendered active, others remain passive for the time being—a condition usually indicated by the presence of lichens, and of certain angiosperms which do not gain a footing whilst the mobile phase persists. The passive phase is well illustrated on parts of the Chesil Bank and by the lateral banks (or landward hooks) at Blakeney, Hurst Castle, and elsewhere. On these, as a rule, the vegetation shows a definite succession—analogous to the resting phase of a sand dune.

The question of the origin of a soil occupying the interstices of the shingle is an all-important matter for the vegetation covering. In part, the soil is formed by lichens and higher plants, the products of whose disintegration may be traced to the deeper layers. This source is supplemented by tidal drift left by the sea and scattered over the bank by the wind. But the most important source of all appears to be the drift on the *landward* side of the bank derived from the salt marshes which are commonly present here. This drift accumulates at the foot of the landward slope in enormous quantities, and is incorporated by the shingle in its slow landward progress. A mobile shingle bank flanked by a salt marsh is a remarkably perfect mechanism for mingling this humus with the shingle. The extreme sterility of many stretches of shingle is doubtless referable to some defect in the working of this mechanism. Whether the drift be withheld, on the one hand, or the onward creep of the shingle (whereby the drift is assimilated), be arrested, on the other, the result will be the same —unless, of course, the bank is so far advanced in its succession as to be self-contained so far as soil is concerned.

A common cause of sterility is the reclaiming (by dyking) of the salt marshes on the landward side, the immediate result being a cessation of the supply of drift owing to the exclusion of the tides from the marshes. Incidentally it may be noted that such starved banks are apt to retrograde and exhibit an unusual degree of mobility, so that shingle is often spread over the marshes on a large scale.

Another cause of sterility is the isolation of portions of a shingle bank from its humus supplies by the accretion of sand dunes.

Perhaps the most unexpected feature of the shingle bank as a habitat for plants is the rich supply of water with which it is provided. Apart from the halophytes which tend to creep up the bank from the salt marsh, the majority of the plant population is non-halophytic. The water, at any rate in the upper zones, is evidently fresh, or nearly so, and its presence requires elucidation. During the current year, notable for its prolonged drought and high temperatures, no drought-effects have been recorded on any of the shingle banks under observation.

In conclusion it may be remarked that a shingle bank is a complicated structure bearing numerous different types of habitat which it will be convenient to discriminate by a separate terminology when the vegetation comes to be more fully studied.

2. *The Swiss National Park and its Flora.* *By* Professor C. SCHRÖTER.

In Switzerland there are now four organisations working for the protection of Nature—the Commission for the Protection of Natural and Prehistoric Monuments; the Society of Swiss Foresters; the Swiss National Trust; and the League for the Protection of Nature ('Naturschutzbund'), which has in two years attained a membership of eleven thousand.

Up to the present the following results have been obtained:—

1. Laws for the protection of plants have been passed in the majority of cantons.

2. Many erratic blocks have been purchased.
3. Especially fine trees have been protected.
4. A 'National Park' of about two hundred square kilometres is in course of establishment in the Lower Engadine. Ninety kilometres have already been acquired.

3. *Phytogeography as an Experimental Science.*
By Professor JEAN MASSART.

Each habitat possesses its own strictly adapted flora. Some species, however, are to be met with in stations which differ markedly from each other. Thus *Koeleria cristata* occurs both on limestone rocks and on sand dunes: *Pelvetia canaliculata* on wave-beaten rocks, and in shallow depressions in salt marshes, and *Veronica hederæfolia* as a weed of cultivation and also in rocky woods.

Sometimes the forms from these different stations have been given special names, *e.g.*, *Matricaria maritima* and *M. inodora*; *Polygonum amphibium natans*, *terrestre* and *cœnosum* (xerophytic). But although they have been separated by systematists, these forms have not in all cases originated by variation. Experiments have proved that some of them are merely the result of plasticity, *i.e.*, the power of organisms to adapt themselves to their surroundings. Thus seeds of *Matricaria maritima* when sown in a garden, at once give rise to *M. inodora*; a cutting of *Polygonum amphibium natans*, planted in wet earth, becomes *P. a. terrestre*, and in dry earth, *P. a. cœnosum*. Conversely, *P. a. terrestre* and *P. a. cœnosum* may just as easily be changed to each other or to *P. a. natans*. But what about *Koeleria cristata albescens*, *Anthyllis Vulneraria maritima*, and the numerous varieties of *Ranunculus aquatilis*? Experiment alone will decide whether they are true systematic varieties or simply adjustments to altered conditions.

The most interesting of these species are those which have the same characters in various habitats, *e.g.*, *Blackstonia perfoliata* looks the same in limestone pastures and in dune valleys. Again, *Pteridium aquilinum* and *Calluna vulgaris* are the same on the limestone pavements of West Ireland as on heaths and moors. What makes these calcifuge species able to grow on limestone in Ireland? Is it because the climate is so extremely favourable that they can withstand the annoyance arising from the calcareous soil? Or because the limestone plants are biologic races, analogous to the races of some parasitic fungi? Or because some particular species whose competition is everywhere too strong on limestone do not exist in Ireland? Direct experiment is the only means of ascertaining whether any of the above explanations be the right one.

The struggle for life no doubt plays an important part in plant-geography. Recent experiments have shown that plants excrete certain substances into the soil, which are toxic to themselves and especially to others. Fairy rings of fungi are probably manifestations of such soil poisoning. When a patch of ground is manured in the middle of a heath and converted into a meadow, the original heath vegetation is unable to re-colonise the cultivated land. Birch trees are not common constituents of forests in calcareous districts, yet they thrive in clefts of limestone rocks where no other trees contend with them. It is likely that the absence of *Calluna*, *Nardus* and *Molinia* on fertile soil, and of birch trees in calcareous woods are mainly due to concurrence. Experiment on such topics would be most welcome.

The origin of species by means of hybridisation is another chapter where experiment takes the pre-eminent place. But here the necessity for experiment has been long recognised, and numerous hybrids have already been studied, both themselves and their offspring. Some very interesting hybrids, however, *e.g.* *Cirsium*, *Betula*, and *Quercus*, have not yet been made.

The power of accommodation, the struggle for life, the origin of species, and other problems of prime importance for phytogeography are now ripe for experimental study.

4. *A Fifteen-year Study of Advancing Sand Dunes.*
By Professor HENRY C. COWLES.

My first observation of the dunes and dune vegetation of Lake Michigan was at Dune Park, Indiana, in 1896. From then until the present time these dunes have been under constant observation, and for most of this time also close study has been made of advancing dunes at Furnessville, Indiana. Occasional trips have been made to the gigantic advancing dunes at Glen Haven, Michigan.

In the three districts studied the dunes are very high, the advancing front having an altitude of twenty-five to sixty-five metres above the country in the path of advance. So high are the dunes and so great is the rapidity of movement that very few of the antecedent plants are able to survive. At Furnessville, where the advance probably is relatively slow, exact measurements have been made by marking the trunks of the trees upon which the dune is advancing; the horizontal advance here is one or two metres *per annum*. At Cape Cod, Massachusetts, *Nyssa sylvatica* sometimes serves as a self-recorder of dune advance.

Oddly enough the plants which are able to survive partial burial by dunes are not Xerophytes (as the pines and oaks), but swamp plants and Mesophytes. As previously described ('Botanical Gazette,' 1899), various species of *Cornus*, *Salix*, and *Populus* often are able to survive a period of dune advance; the shrubby species are stimulated thereby to extraordinary stem elongation. The early assumption that survival depends upon the capacity of a plant to put forth adventitious roots and to elongate as rapidly as the dune advances has been shown to be correct. Such Mesophytes as *Tilia americana* and *Ulmus americana* are quite as able to endure dune encroachment as are poplars and willows, and for the same reasons. At Furnessville there are elms thirty metres in height above the original country level; at the present time the tree-tops project only one or two metres above the sand, but their foliage is healthy and they flower and fruit vigorously.

5. *On the Brown Seaweeds of a Salt Marsh.* *By* Miss SARAH M. BAKER.

The capability of giving rise to marsh forms seems to be shared by all the brown seaweeds inhabiting the upper parts of rocky shores. *Pelvetia canaliculata, Fucus spiralis, Ascophyllum nodosum*, and *Fucus vesiculosus*, all show marsh varieties or species. The reason that *Fucus serratus* and *F. ceranoides* have no representatives in the marsh habitat is probably their intolerance of desiccation.

The physical and chemical environment factors on the marsh being much more complex and varied than on a rocky shore, one would expect a corresponding variation in the structure of its plants. The most marked characteristics of the common marsh species are a great tendency to spiral twisting or curling of the thallus—and vegetative reproduction. That this latter feature is not directly caused by the marsh habitat is shown by exceptional species where reproduction is normal.

The zoning of the brown seaweeds of a marsh is often very striking; but the factors governing it must be far more complicated than those operating on the seashore.

The extensive mattings of brown seaweeds often found on English marshes have a decidedly beneficial effect on the phanerogams. It seems possible that *F. volubilis* may act as a pioneer in the establishment of salt marshes in certain cases.

6. *The Causes of the Formation of Hairs and Palisade Cells in certain Plants.* *By* Professor R. H. YAPP, *M.A.*

It has long been known that many plants have a marked power of responding by structural changes to a varying environment. This is markedly true in respect of the palisade tissue of leaves, and the hairs on aërial shoots. The results of many previous observers and experimenters show that in general both palisade cells and hairs tend to develop best under conditions which either

favour transpiration or hinder absorption. The author has confirmed these results in the case of *Spiræa Ulmaria*, and traced the history of the development of both kinds of cells in detail. The relation of the hairs and palisade cells to external factors has also been followed at each stage of development.

The conclusion arrived at is that the initial stimulus leading to a marked development of these special cells is to be sought in a diminished water-supply in the cells themselves. On the other hand, a considerable degree of turgor is necessary for the actual stretching growth of the cells. In all probability these apparently opposed conditions occur more or less regularly in Nature, in the form of periodic fluctuations of turgor. Thus transpiration during the daytime (especially when excessive) would afford the stimulus of diminished turgor; while the increasing turgor of the cells during the night-time would allow of their actual growth.

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7. *The Forest Stages represented in the Peat underlying the Moorlands of Britain. By* F. J. Lewis, *D.Sc., F.L.S.*

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8. *Types of Vegetation in the District round Macclesfield.*

By Miss Lilian Baker, *M.Sc., and* B. W. Baker, *B.A.*

Introduction.—The area being studied comprises parts of Cheshire and Staffordshire, the county boundary running across the south-east corner of the tract. The four corners are approximately marked by the towns of Northwich, Crewe, Leek, and Macclesfield. It includes part of two regions—namely, (1) the *Cheshire Plain*, occupying the western portion, largely cultivated, with numerous parks and wooded estates, and a few sandy heaths and 'mosses'; and (2) the *Pennine Foothills*, occupying the eastern portion. The latter consists of approximately parallel ridges, intersected by the Dane Valley and other wooded ravines, and covered by moors. The highest altitude, that of 1,500 feet, is attained by the bleak moorland tract of Macclesfield Forest.

The total rainfall may be said, generally, to increase from the level western parts towards the hilly east. The plotting of monthly rainfall curves has shown that there is considerable local variation from the curves for Great Britain.

Geology.—The two regions of the sheet show marked differences in structure. The Plain consists of Triassic rocks, buried in Pleistocene times under a thick covering of glacial deposits—boulder-clays, sands, and gravels. The hill region consists of Carboniferous rocks occurring in the following strata: (1) Coal measures, (2) Millstone grit series, (3) Pendleside series, (4) Carboniferous limestone. The shales of the Pendleside series, being most easily eroded, are found to occupy river valleys, the other strata standing out in bold relief. The distinction between the hard grits and the softer crowstones influences the contour of the land as well as the character of the soil.

Peat mosses occur on the Plain in the position of former Glacial lakes, but have been largely reclaimed.

Vegetation.—*Moorland and Heath Associations* are represented by:—

(1) *Vaccinium Myrtillus*, either pure or with more or less *Calluna*. Its replacement by *Empetrum nigrum* presents interesting features, *e.g.*, the summit ridge of Congleton Edge, proceeding in a north-easterly direction, shows the following succession: (*a*) *Calluna vulgaris* with *V. Myrtillus*, *Eriophorum angustifolium*, *Erica cinerea;* (*b*) *Vaccinium Myrtillus* with *Calluna vulgaris;* (*c*) *Pteris aquilina* with *V. Myrtillus* and *C. vulgaris*; (*d*) *Pteris aquilina* with *V. Myrtillus* and *Empetrum nigrum*; (*e*) *Vaccinium Myrtillus* with much *Empetrum* and little *Calluna*.

(2) *Eriophorum angustifolium*, with or without *Calluna*, according to the amount of moisture present.

(3) *Calluna vulgaris*, with different accompanying plants, according as it occurs on peat or on sandy soil.

(4) *Sphagnum*, in restricted areas, *e.g*, on Brookhouse Moss, formerly occupying large tracts, the old lake-beds, as shown by the constitution of the peat on Dane's Moss.

Grassland Associations are represented by heath pastures of varying composition. In many cases these have been reclaimed by drainage or by burning the heather. They are, as a rule, replaced by heather moors at an altitude of 800-1,000 feet. On the whole, they are becoming more extensive, at the expense of the 'mosses' and moors.

Woodland Associations.—These are less extensive than formerly, and are chiefly represented in parks and large estates. In the hilly parts, they are chiefly coniferous or mixed; in the lower parts, oak or birch, or both.

(1) *Pinus sylvestris* has been widely planted, and above the 1,000-foot level is frequently associated with a heather-moor vegetation. Larch also occurs in coniferous and mixed woods.

(2) *Betula alba* occurs in plantations and natural woods, together with larch, pine, oak, alder, &c., at low altitudes, and with oak, in stunted woods, at higher elevations. In the former situations it generally has an undergrowth of *Pteris aquilina*; in the latter, of a more heath-like character.

(3) *Oak-woods* can be divided into two types: (i) Damp oak-woods, of the oak-birch-ash type, occurring on the Plain and in the ravines. *Quercus robur* is the dominant species, and the undergrowth contains *Epilobium hirsutum*, *Digitalis purpurea*, *Agrostis alba*, and *A. canina*. (ii) Dry oak-woods on summit ridges and similar exposed situations, *e.g.*, the grits of Congleton Edge. *Quercus robur* is here accompanied by much *Q. sessiliflora*, and the undergrowth consists of *Pteris aquilina*, *Vaccinium Myrtillus*, *Aira flexuosa*.

Aquatic Associations present a considerable number of species, and are: (1) Rooted with submerged or floating leaves; (2) Reed marsh; (3) Marginal plants.

Pasturage.—There is a high percentage of land under permanent grass, the clayey loams being too heavy for wheat. The heavy rainfall favours the growth of grasses, which, with their accompanying plants, form an interesting study. Agriculture occupies a subordinate place in the district, though a good yield is obtained for root crops.

FRIDAY, SEPTEMBER 1.

The following Papers were read :—

1. *The Structure and Development of the Ovule of* Bowenia spectabilis. *By* Miss E. M. KERSHAW, *M.Sc.*

The development of the ovule agrees on the whole with that described for other genera of Cycads. Certain points in the study of the Cycadean ovule appear to require more critical consideration for the purpose of comparison with the fossil seeds. The pollen-chamber of Bowenia forms by the breaking down of a strand of elongated cells which extend from the tip of the nucellus almost to the megaspore. First a small cavity, *the upper pollen-chamber*, forms in the narrow apex of the nucellus, and this probably accommodates the pollen when it enters the ovule. The nucellar tissue below gradually breaks down, forming a more capacious cavity, *the lower pollen-chamber*, into which the pollen grains pass from the *upper pollen-chamber*. The upper and lower pollen-chamber thus correspond in function to the 'lagenostome' and 'plinth' of such fossil seeds as Conostoma. They are, however, much less specialised and altogether simpler than the corresponding structures in the seeds of the Lagenostomales, and appear to be more comparable with seeds of the Trigonocarpus affinity.

The examination of the nucellus and integument of older ovules of Bowenia suggests that the inner vascular system is to be regarded as nucellar and not integumental—a further point in favour of comparison with seeds of the Medullosæ.

Stages in the development of spermatozooids have been studied in Bowenia which show that this genus agrees with more fully studied Cycads.

2. *The Structure of a New Type of Synangium from the Calciferous Sandstone Beds of Pettycur, Fife, and its bearing on the Origin of the Seed. By* Miss M. J. Benson, *D.Sc.*

The Synangium is attributed on structural grounds to *Heterangium Grievii*, and probably represents the pollen synangium of that plant. It differs from all hitherto described synangia in the variety and large proportion of its sterile tissue. This sterile tissue shows the sclerotic plates characteristic of the inner cortex of *Heterangium Grievii*. Numerous vascular bundles with hydathodal ends occur, and irregular longitudinal dehiscence was brought about by the swelling of hygroscopic fibres. Another wholly new feature is the occurrence of both central and peripheral loculi (four central and twelve peripheral). The loculi agree in size and form with those of the incrustation fossil, *Diplothecra stellata* (Kidston), which is identified as the same synangium in a dehisced phase. The discovery of the structure of this early synangium adds fresh confirmation to the synangial theory of the seed, which may be restated as follows: The Palæozoic ovule of the Lagenostoma type may be regarded as the product of the elaboration of a synangium comparable with the above—the megaspore or embryo sac being derived from the central group of loculi, and the canopy and peripheral part of the ovule from the peripheral part of the synangium with its envelope, twelve loculi, cortical tissue, and vascular bundles.

3. *A Palæozoic Fern and its Relationships* (Zygopteris Grayi, *Williamson*). *By Dr.* D. H. Scott, *F.R.S., Pres. L.S.*

The simpler Palæozoic Ferns (Primofilices of Mr. Arber, Cœnopterideæ of Professor Seward) have received much attention of late, especially in the fine memoirs of M. Paul Bertrand.

Zygopteris Grayi, a species founded by Williamson in 1888, on somewhat imperfect material, occurs both in roof and seam nodules of Lancashire coal-beds, but is very rare. Besides the specimens described by Williamson, there is a much better one, the sections of which are partly in his collection; this has been figured by the author in 1900, by M. Paul Bertrand in 1909, and by Mr. Kidston in 1910, but never adequately.

Last year a fine series of sections of an entirely new specimen from Shore, Littleborough, was received from Mr. Lomax, and forms the basis of the present communication.

The new specimen shows the general characters of the *Z. Grayi* type: a five-rayed stellate stele, the corresponding $\frac{2}{5}$ phyllotaxis, leaf-trace bundles with axillary shoots, scale-leaves or aphlebiæ, and adventitious roots. The characteristic internal xylem, consisting of narrow tracheides embedded in parenchyma, is particularly well shown, both in the main stem and in the axillary stele.

This specimen affords clear evidence that it belongs to the genus *Ankyropteris*, as defined by P. Bertrand. The leaf-trace and foliar bundle show perfectly the peripheral loops of small-celled xylem characteristic of *Ankyropteris*. The loops begin to be differentiated long before the leaf-trace separates from the stele. This confirms P. Bertrand's own view; he found peripheral loops in Williamson's specimens, where, however, they are usually very obscure compared with those in the Shore plant.

Stenzel's species, *Z. scandens*, which Williamson was at first inclined to identify with his *Z. Grayi*, is probably also an *Ankyropteris*, but does not appear to be identical with the Shore fossil.

The latter is somewhat peculiar in the form of the leaf-trace, which is

crescentic in section, instead of being approximately triangular as figured in Williamson's and Stenzel's plants. A similar crescentic trace occurs, however, in some of Williamson's sections of the specimens described in 1888. The evidence of the new specimen is distinctly in favour of the view that the large strand given off from the stele is really a leaf-trace and not itself a branch. The branch which the leaf-trace gives off higher up may thus retain the name of *axillary shoot*, originally bestowed upon it by Stenzel.

The origin of the peripheral loops and the continuity of the protoxylem of the leaf-trace with that of the stele can be followed in the serial sections.

The course of the aphlebia-strands, which are given off by the leaf-traces both before and after their separation from the stele, can also be followed.

The author inclines to the view that the *Z. Grayi* type of stele represents an elaborated protostele, rather than a condensation of a more complex vascular system. On the other hand, the relation to the stem of *Diplolabis Römeri*, described by Mr. Gordon, would be a collateral one rather than a direct filiation.

4. *Recent Researches on the Jurassic Plants of Yorkshire.*

By H. HAMSHAW THOMAS, *M.A.*

Since the formation of the large collections of fossils from the Yorkshire coast by Williamson, Bean, Leckenby, and other enthusiastic collectors, few plant-remains of importance have been obtained from this famous locality. In 1879 Professor Nathorst, of Stockholm, had obtained a number of new and interesting forms, and during a visit in 1909 he made further important discoveries, on which the first of his recent papers on *Williamsonia* was based. It became clear that much further information about the flora of Jurassic times might be obtained by renewed researches in Yorkshire, and the present paper is a brief summary of some of the results obtained by Professor Nathorst, Dr. T. G. Halle, and myself.

Important additions to our knowledge of the Bennettitales have been made by Professor Nathorst. He distinguished, for the first time, the male sporophylls of *Williamsonia,* which are united together into a cup-like structure somewhat comparable with a flower. The sporophylls are more or less covered with large sessile synangia from which the remains of the microspores can be extracted in great numbers by treatment with acid in the usual way. *Williamsonia* appears to have been unlike most of the *Bennettites* (or *Cycadeoidea*) in having unisexual 'flowers.' Several species of male 'flowers' have been distinguished, which differ in the number and the arrangement of the synangia. In some forms a considerable reduction in the number of synangia seems to have taken place. The female strobilus of *Williamsonia* bears a close resemblance to the corresponding structure in *Bennettites.*

I have recently discovered near Gristhorpe a new Bennettitalian 'flower' which appears to be bisexual. The central axis bore the usual ovules and interseminal scales, and below this there was a whorl of five or six large free sporophylls, arranged in a similar way to the petals of a hypogynous flower. On these sporophylls five or six large reniform sporangia were borne.

Some facts in the history of seed-bearing plants will probably be furnished by the study of some small fruit-like bodies which I have recently found and have named *Caytonia.* They appear to contain the remains of eight to ten seeds, each 1 to 2 mm. long, and similar isolated seeds have been obtained. A certain amount of their structure has been preserved, and parts of the integuments, nucellus, and micropylar tubes can be made out.

Some additional information has been obtained about the mesozoic ferns. Dr. Halle has found that the sporangia of some specimens of *Cladophlebis denticulata* were pear-shaped and had an apical cap of thickened cells. He suggests the affinity of these with *Seftenbergia.* I believe that the sporangia of Todites, which are arranged much as in the modern Todea, possessed a similar apical cap of cells, and were in this respect different from the recent forms.

The sporangia and spores of *Coniopteris hymenophylloides* have been discovered and show resemblances to those of some of the modern Cyatheaceæ. Fertile specimens of *Cladophlebis lobifolia* have been obtained which are somewhat similar to recent Dicksonias in the form of the sori and spores. The

sporangia have not yet been clearly seen. We are now able to go a short distance towards splitting up the old artificial genus *Cladophlebis*.

Several plant-remains new to Yorkshire have been found, such as *Neocalamites* at Whitby, *Marattiopsis* at Marske, and a structure resembling the sporocarps of a *Marsilia* at Gristhorpe. It seems probable that future work will yield many further interesting results.

5. *A Petrified Jurassic Plant from Scotland.*
By Professor A. C. Seward, *F.R.S.*

This paper dealt with the structure of a petrified *Williamsonia* collected by Hugh Miller in North-East Scotland, and figured by him in the 'Testimony of the Rocks.' The specimen, of which sections have been cut by permission of the Director of the Royal Scottish Museum, Edinburgh, consists of a central conical axis bearing immature interseminal scales and seeds, the whole being enclosed by linear bracts bearing numerous unicellular hairs. The structure of this fossil will be fully described in a forthcoming paper.

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6. *A Contribution to our Knowledge of the Formation of Calcareous Nodules containing Plant Remains.* *By* Miss T. Lockhart, *B.Sc.*

Three boulders from the calciferous sandstone of Pettycur had been entirely cut into thin serial sections in the search for a minute object, and it was thus possible to trace the position, in a block, of any particular plant.

Metaclepsydropsis duplex and *Botryopteris antiqua* were chosen, as they presented a contrast between a large and a small plant. The clear delimitation of even the smallest fragments points to mechanical fracture subsequent to immersion, and the parallel position of plant remains in the boulder further indicates the agency of water currents.

The results confirm Dr. Gordon's views of thermal pools as the actual site of petrifaction.

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7. *Nuclear Osmosis as a Factor in Mitosis.*
By A. Anstruther Lawson, *D.Sc.*, *F.R.S.E.*

A study of the microspore mother-cells of *Disporium*, *Gladiolus*, *Yucca*, *Hedera*, and the vegetative cells in the root-tip of *Allium*, has revealed a series of stages in the development of the mitotic spindle which has never before been recorded. The new stages that have been discovered are to be found in the prophase, immediately preceding the organisation of the equatorial plate, and concern the fate of the nuclear membrane. The interpretation of these stages has thrown a new light on the process of mitosis, and necessitates a revision of the accepted views of nuclear phenomena. Contrary to the generally accepted view, it has been found that the nuclear membrane does not break down or collapse at any period during spindle development, but behaves as one would expect a permeable plasmatic membrane to behave under varying osmotic conditions.

The nucleus is regarded as an osmotic system, and its membrane constitutes an essential element in that system. It is a fact of common knowledge that the chromatin changes both in quantity and form some time before the metaphase. The chromatin must increase in quantity because the same amount is present with each mitosis. It changes in form from the finely divided condition represented in the reticulum and spireme to the more compact and homogeneous form of the chromosomes. It would seem that these changes are in some way correlated with a variation in the osmotic relations of the karyolymph. At any rate, a gradual diffusion of the nuclear sap immediately follows these changes in the chromatin.

A series of stages has been found showing beyond much doubt that closely following the organisation of the bivalent chromosomes there takes place a gradual diminution in the volume of the nuclear vacuole. It is believed that the karyolymph gradually diffuses by exosmosis into the cytoplasm. Through-

out the entire prophase the nuclear membrane is functional in this osmotic transfer. As the nuclear vacuole becomes smaller and smaller the membrane gradually closes in about the chromosomes. When the karyolymph becomes so much reduced that it is no longer visible as a clear nuclear sap, the membrane becomes closely applied to, and completely envelops, the surface of each chromosome.

For some time previous to the diffusion of the karyolymph the nuclear vacuole occupies a space that may approach or even exceed in size half the volume of the cell-cavity. So that all of these circumstances bring about a condition where a limited amount of cytoplasm of reticulate structure is obliged to occupy a cubical space which has greatly increased by reason of the reduction in the volume of the nuclear vacuole. This necessarily sets up a tension in the cytoplasm —a tension sufficient to cause a readjustment and changed configuration in the reticulate form of the cytoplasm. As the nuclear vacuole becomes smaller and smaller, the cytoplasm in the region of the nuclear membrane becomes changed to the form of fine threads or fibrils which are drawn out from the reticulum by the receding membrane. The state of tension set up in the cytoplasm thus finds an expression in the drawn-out threads of 'kinoplasm.'

From the different plants studied it seems that the lines of tension as expressed in the fibrils may group themselves in various ways at first. Thus we may have a weft of kinoplasm about the nucleus; or a system of kinoplasmic radiations; or more commonly a number of conical-shaped sheaves of fibrils. But whichever form the kinoplasm may appear to take, the lines of tension are constantly shifting throughout the prophase. Such a shifting does not mean the changing of the threads bodily from one position to another. It means the relaxing of the tension along certain threads—which would consequently fall back into the reticulate form—and the setting up of new lines of tension by the drawing out of threads from the undifferentiated reticulum. In this fashion not only individual threads but entire sheaves or cones of fibrils may appear to assume different positions. The generally accepted view that the sheaves or cones approach one another and coalesce in two groups can be no longer retained. There was no evidence to support the view that the spindle fibrils grow into the nuclear area and attach themselves to the chromosomes. This attachment is undoubtedly brought about by the enveloping of each bivalent chromosome by the receding nuclear membrane. This investigation lends no support to the view that the attached fibrils draw the daughter chromosomes to the poles of the spindle.

The achromatic figure as we see it in the vascular plants can no longer be regarded as an *active* factor in mitosis. It is simply the *passive* effect or expression of a state of tension set up in the cytoplasm—a tension caused in the first place by nuclear osmotic changes.

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8. *The Longitudinal Fission of the Meiotic Chromosomes in* Vicia Faba.

By Miss H. C. I. Fraser, *D.Sc.*

In the telophase of the vegetative divisions the chromosomes of *Vicia Faba* undergo longitudinal fission; this fission persists, forming the line of separation of the daughter chromosomes in the succeeding prophase. Fission takes place as usual in the telophase of the last vegetative division in the archesporium, and when the preparation for meiosis begins the reticulum consists of split threads united to one another both by their ends and laterally.

The longitudinal fission is recognisable throughout the synaptic stage, and is responsible for the V shape of the chromosomes on the heterotype spindle.

At the poles the V s come into contact, become attached to their neighbours, and undergo a second longitudinal split. Both fissions are recognisable till the chromosomes pass on to the homotype spindle, where, as a result of the first fission, they still have the form of Vs. The first fission—that initiated in the last archesporial telophase—being now completed, the daughter chromosomes pass up the spindle as rods. The second fission, obliterated during the metaphase, is renewed as the chromosomes come into contact with their neighbours at the pole and is recognisable in the haploid reticulum.

9. *The Life-Cycle and Affinities of the* Plasmodiophoraceæ.

By T. G. B. Osborn, *M.Sc.*

During the last few years there has been a considerable increase in our knowledge of the Plasmodiophoraceæ, largely owing to the work of Maire and Tison.

The life-cycle, as far as it has been described for the following genera, *Plasmodiophora, Sorosphæra, Ligniera,* and possibly *Tetramyxa,* consists of the following stages :—

(1) A schizont stage in which the nuclei divide in a distinctive manner.
(2) An akaryote or chromidial condition after the close of the vegetative phase.
(3) The nuclei are subsequently reconstructed, and pass through stages of synapsis, diakinesis (in the first two genera at least), and a double mitosis, regarded as reduction divisions, after which uninucleated masses of protoplasm become encysted. Prowazek's observation of a pæodogamy in the sporocysts of *Plasmodiophora* lacks confirmation and support.

Spongospora subterranea has recently been shown to have just such a similar life-cycle as that outlined above, with one important addition. Following the akaryote condition, the nuclei arrange themselves in pairs and then unite. A condition resembling synapsis succeeds the karyogamy, and is followed by two karyokinetic divisions.

An examination has been made of *Plasmodiophora brassicæ,* with the result that appearances suggestive of fusion in all its stages have been observed. The evidence is supported by a reduction in the number of nuclei and their increase in size before the first karyokinetic division.

By the kindness of Dr. Blomfield and Mr. Schwartz I also have been able to make a comparison with *Sorosphæra veronicæ,* and here similar phases have been observed.

Maire and Tison have seen a pairing of the nuclei in *Sorosphæra* suggestive of karyogamy, but for them the pairing is merely the telophase of division or else accidental juxtaposition. Against the appearances here described being the telophase of division is the fact that the nuclei are those of the sporont and not the schizont. Against accidental juxtaposition, in addition to the appearances directly suggestive of fusion, there is the improbability that more than half the nuclei in a plasmodium would be paired, and also the fact that the nuclei are reduced in number while they are increased in size previous to karyokinesis.

These observations tend to strengthen the suggested relationship of the Plasmodiophoraceæ to the Myxomycetes, since their sexual life-cycle has so many features in common. The connection of the Plasmodiophoraceæ, through *Ligniera* and *Rhizomyxa,* with the Chytridineæ put forward by Maire and Tison on morphological grounds, has received valuable support from the cytological point of view by the observations of Némec on *Sorolpidium.* While further critical work is needed on these organisms, it may be pointed out that the suggested affinities are not mutually incompatible.

10. *Somatic Nuclear Division in* Spongospora Solani (*Brunck.*).

By A. S. Horne, *B.Sc., F.G.S.*

During the early stages of the life-history of this parasite (vegetative phase) the nuclei divide by a peculiar form of karyokinesis. During prophase a definite spireme is formed. Ultimately, four loop-shaped chromosomes appear. These, during metaphase, join end to end to form an equatorial ring about the persistent nucleus. This ring divides into two daughter rings. Each of the latter, during anaphase, breaks up into four chromosomes.

The nucleolus constricts, during anaphase, to form two daughter nucleoli. The divisions appear to take place within the nuclear membrane. Spindle-fibres, few in number, have been distinguished. No centrosomes have been observed.

After a time the nuclei cease dividing by this form of karyokinesis. A period of chromidial activity ensues, which affects the parasite whether in the form of myxamœba, cœnocyte, or plasmodium.

The spindle-figures which are formed in these divisions vary considerably in size. Centrosomes are present. The nucleolus may persist; if so, it is often

not easily distinguishable. Four loop-shaped chromosomes are present. Their behaviour on the spindle appears to be normal. Spindle-fibres, few in number, have been observed.

It is difficult to determine how many divisions precede spore formation. The spindle-figures of the first division are relatively larger than those of the succeeding divisions. The nucleolus persists and divides during anaphase to form two daughter nucleoli. The spindle-figures of the last division (that immediately preceding spore formation) are exceedingly small.

Nuclear division within the spore has not been observed.

11. *Preliminary Note on an Investigation of some West African Fungi.* *By* A. Eckley Lechmere, *M.Sc.*

A series of cultures made from fungi collected in the Virgin Forest of the Côte d'Ivoire (French Congo) have yielded some interesting forms. Amongst others a series of three forms have been isolated, showing a life-history of great interest. Each of these shows the formation of distinct perithecia containing numerous asci with eight ascospores. When quite ripe dehiscence takes place by means of emission of a long thread-like mass of ascospores from an irregular terminal pore exactly recalling the emission of sporidia in certain genera of the Sphæriaceæ, in other characters these species closely resemble the group Perisporiaceæ. The three forms, although exactly comparable as regards their perithecia and asci, differ considerably as regards their asexual form of reproduction.

The first form 'L^2' has no other form of reproduction except the perithecia. The second form 'A' shows a plentiful production of 'oidial' cells in the mycelial filaments to such an extent that after a week's growth the whole mycelium is completely black. The third form 'B' shows the formation of conidia of the 'Coramium' type.

All attempts to get a transition from one form to the other have been so far unsuccessful, the three forms remaining true to their characters in pure culture.

As to the position of these fungi, it is not yet possible to classify them with any accuracy; they seem at any rate to belong to a new genus, and occupy a position in the Pyrenomycetes somewhere between the groups Perisporiaceæ and Sphæriaceæ.

MONDAY, SEPTEMBER 4.

Joint Discussion with Sections C and E on the Relation of the present Plant Population of the British Isles to the Glacial Period. Opened by Clement Reid, *F.R.S.*

The distribution of our British plants has long been a puzzle to the botanist, and no explanation was forthcoming till the cause was searched for in bygone changes of climate, and changes in the distribution of land and sea. A century ago it was generally supposed that species had originated mainly in the districts in which they were then found. But even under this hypothesis the anomalies of discontinuous areas seemed to require explanation, for the same species was not likely to originate at several different points.

With the growth of the idea of gradual evolution it was realised that faunas and floras had a past history, even if the included species had remained unchanged. Botanists recognised that there were many points that required explanation. For instance, it was noticed at an early date that each of our mountain-tops possessed a small outlying fragment of the arctic flora. How came it that the same species occupied so many different mountains? This seemed a perfectly fair subject of inquiry, even to naturalists who hated the very idea of evolution when applied to species and genera.

More than sixty years ago a great impetus was given to this study by the discovery that Europe had passed through a most remarkable series of climatic changes, and that, too, during the lifetime of the existing species of animals and plants. There had not been a mere cooling of the climate; the temperature in these latitudes had sunk far below its present level, and then had again risen.

Edward Forbes, in 1846, seized this clue, and explained through it, as relics of the Glacial Period, the arctic plants stranded on our mountain-tops; they were plants left behind when the climate became too warm for them any longer to survive on the plains. The subsequent discovery of fossil remains of these plants scattered over the plains, and often associated with relics of arctic animals now extinct in Britain, seemed a brilliant proof of Forbes' view, which has been generally adopted.

In some curious way, however, botanists and zoologists both seem to have overlooked the difficulty that, granting Forbes' hypothesis to be sufficient to account for our alpine flora, it rendered more difficult instead of easier the explanation of our southern flora, which occurs in a similar way stranded in some of the warmest low-lying parts of Britain.

We meet to-day to discuss this question, in the hope that botanists, zoologists, and geologists may realise each other's difficulties, and may be able in combination to give a clear teaching on this important problem of geographical distribution.

The discussion I have been asked to open is limited to the relation of the present Plant Population of the British Isles to the Glacial Period. Our problem is a special one; it is not the same as that which confronts the botanist on the Continent of Europe or America; and it is not the problem of the origin of the flora of an oceanic island. Also, the wider question of the origin of the species composing the British flora is outside the discussion, for it would lead us into too many untrodden bypaths, and could not satisfactorily be gone into in the present imperfect state of our knowledge.

Perhaps it will be well to explain at once why the inquiry is thus limited to comparatively recent periods, and how it is that we need not explore the unknown earlier periods and deal with larger questions.

Our first inquiry in this case must be: Has there been any continuous occupation of Britain by a temperate flora and fauna from pre-Glacial times to the present day? Or, to put it in other words: Are any of our plants survivors that managed to live through the cold of the Glacial Period in some warm nook in Britain? They evidently found a refuge somewhere, for we know that the same temperate species that live in Britain now were here in pre-Glacial times. But was this refuge in Britain?

Here geology comes to our aid, and I think that all geologists who have made a special study of the climatic conditions will agree with me. Any survival of our flowering plants, except in the case of a few arctic and alpine species, was quite impossible.

It may come as a shock to some of my colleagues when I say that for this particular discussion we have a perfectly definite starting-point. We have merely to account for the incoming of our existing flora, after an earlier assemblage had been swept away almost as completely and effectually as the celebrated volcanic eruption wiped out the plants of Krakatoa.

In order to make clear the existence of this limitation, and for the convenience of the discussion, I have prepared certain maps, which are now shown. I propose now to say a few words as to the bygone climatic and orographic changes indicated on those maps, and on their bearing on the existing flora of Britain. I must say at once, however, that you must not take these maps as absolutely exact statements as to the climatic and geographic conditions at the different stages involved in our inquiry. But they give the result of many years' work at this subject, and, I think, may be accepted as embodying the main factors which dominate the question we have to discuss.

We know that during the greatest intensity of the cold all Scotland, Ireland, and the greater part of England were buried under ice and snow—except, possibly, for some high peaks on which a few arctic species survived. Ice filled the North Sea and covered the lowlands of England down to the mouth of the Thames. Without crossing the Thames it almost reached London. Its southern

limit stretched to South Wales, where tongues of ice reached the Bristol Channel in big glaciers like those of the Antarctic Regions or Greenland. In South Wales a few hills may have escaped, though surrounded by ice.

The glaciation in Ireland was even more extreme, for apparently no part of Ireland escaped. Even the warmest parts of the south-west are striated and covered by morainic material, the ice extending well out into the Atlantic. The icebergs were so big, or the ice-foot so thick, that, breaking away from the Irish coast, the masses were able to float across to the Scilly Isles before they melted; for they carried with them numerous striated stones of well-known rocks, now found stranded on the highest parts of the Isles of Scilly. Thus it is evident that in those days Scilly, our most southerly and warmest point, was surrounded by a bitterly cold ocean, and it was submerged to such an extent that it could be overridden by pack-ice. Could any temperate plant survive such treatment? I particularly want you to realise the climate that Scilly enjoyed in those days, for it is now one of the warmest spots in our islands, and its temperate flora has come back, though the islands are surrounded by fairly deep sea.

It seems evident, therefore, that a temperate flora could not have survived the cold in Ireland or in the Scilly Isles. But there is still the non-glaciated area south of the Severn and Thames to consider, and botanists may tell us that the temperate flora survived in some warm nooks in Devon or the Isle of Wight. Here, however, we can point to evidence that the botanist himself must accept as conclusive.

In the south of Devon one of the warmest of the sheltered valleys is that through which the Teign flows to Newton Abbot. But in the alluvial deposits of this valley, and only a few feet above the sea level, Professor Oswald Heer and Professor Nathorst discovered leaves of the dwarf Arctic birch and some Arctic mosses.

Time will not allow us to go into all the evidence; so I will only point to one or two other areas which prove the extreme rigour of the climate in the South of England. Close to Salisbury are found in profusion remains of various Arctic mammals—reindeer, musk-ox, Arctic fox, lemming, and several others. Unfortunately plants do not seem to have been searched for, and the sections were obscured when I visited the pit; however, the flora associated with this assemblage of mammals can only have been the flora of the Arctic regions.

To come nearer home, around Portsmouth itself we have abundant evidence of this icy sea, for in the peninsula of Selsey especially we find numerous large erratic blocks floated by ice. Some of them have been identified as coming from the Isle of Wight, others from Bognor and Cornwall, and a number came from the Channel Islands. Thus even the north coast of France had its shores fringed with ice.

I have attempted to show on a map what the Channel was like when Spithead was thus blocked with ice-floes. Is it possible to believe that the plants of the south of England, many of which can barely hold their own during a severe winter nowadays, could have survived these arctic conditions?

If the southern plants were completely swept away by the cold, the question arises: How did they come back again, especially to islands like Ireland and the Isles of Scilly, and how did they obtain their very singular present geographical distribution? We are told that the matter is simple enough, for Britain has often been connected with the Continent, and the plants spread slowly overland. However, before we adopt the view that for animals and plants to spread to islands it is needful to have land-connection, you should remember Krakatoa, and the rapidity with which the exterminated flora has come back. Also I must point out that there are peculiarities in the distribution of the different elements that go to make up the existing British flora that no land-connection will explain. Look at the recent distribution. One of the most striking peculiarities is the Pyrenean element in our flora. It is practically confined to two areas, the one in Cornwall and the other in the West of Ireland. Geologists nowadays will not agree to the reconstruction of a lost Atlantis to account for this peculiar distribution.

Undoubtedly since the Glacial Period our islands have seen several oscillations of level. There has also been widening and narrowing of straits and channels. England has been connected with France near Dover, and also across

the North Sea with Holland and Denmark. But 20 or 25 metres seems to have been the approximate extent of the rise in the south of England. I have searched in vain for evidence of a greater movement. A shallowing of the sea by 25 metres is not nearly sufficient to connect Ireland with England, or Scotland, or the Isles of Scilly with England. Still less would it suffice to connect the West of Ireland or Cornwall with the Pyrenees, where the peculiar plants find their home. A rise of land to this amount would not even bring Scilly and the Land's End appreciably nearer together.

This limitation of the extent to which we can bridge over the gaps between our islands is, however, a point on which there is much difference of opinion, and I will not insist on the conclusiveness of the evidence as to the extent of the oscillations.

From the botanist's point of view there are, however, other archipelagos besides those surrounded by water. No doubt if we can postulate sufficient orographic changes plants would spread slowly from land to land during the few thousand years that have elapsed since the cold died away. But—and this 'but' is all-important—they would only do so if the soils were suitable. An isolated tract of limestone surrounded by clay or by sand is as much an island, as far as many of our most peculiar plants are concerned, as if it were surrounded by water. We have many such islands—or oases is perhaps a more suitable term for them—and no possible ups and downs of the land will connect them. Many of them, like the central limestone district of Ireland, or the Peak District in Derbyshire, or the West Yorkshire carboniferous limestone, must have been isolated from far-distant geological periods, from times before the present flora of Britain had any existence. We have a still more difficult problem than this. Britain is divided into numerous river-basins, for most of which any connection with other basins in post-Glacial times is unthinkable. Yet each basin yields numerous aquatic plants and animals of the same species as those found in other basins cut off by high hills. Isolated lakes have their aquatic flora; and even artificial ponds, such as the dew-ponds of our high chalk downs, have a fauna and flora closely proportionate in the number of species with the time that has elapsed since the pond was made, or since it last dried up. If no actual connection between river-basins or isolated ponds is needed for the spread of aquatic plants, why need we postulate a land-connection for the land-plants, or a bridge of limestone to aid the migration of the limestone plants from crag to distant crag? Aquatic plants and limestone plants must obviously in most cases have taken leaps of many miles to arrive at their present stations. Our plants have far greater power of crossing deserts and seas than most botanists are willing to allow.

Let us examine the present distribution of one of the most interesting groups of British plants. The Atlantic or Lusitanian plants form an assemblage belonging mainly to the Pyrenees, and found also in the S.W. of England, and again in S.W. Ireland. But they do not occur in the intermediate districts. If we look more closely into the composition of this Atlantic flora, as it is represented in Britain, we find that only plants with small seeds have been able to cross to Cornwall and Ireland, those with large seeds being left behind on the Continent. There is only one tree among them, and that is the *Arbutus*, one of the few trees with minute seeds now living in Europe. A further examination confronts us with the puzzle that, whilst various Pyrenean species are found also in Cornwall and Kerry, the species occurring in Cornwall and Ireland are not the same. The *Arbutus* is a case in point; it is wild in Ireland, but in no part of England. *Erica ciliaris* and *E. vagans* are English, and not Irish; *E. mediterranea* is Irish, and not English.

The local distribution of these plants is equally strange. A few, like *Pinguicula lusitanica*, have spread throughout the West Country, wherever the conditions are suitable. Most occur, however, in quite different fashion; they are abundant over certain limited areas, to which they are strictly confined, but they are absent from other adjoining areas, though equally suited. I have mapped and examined a good many of these areas, and the plants seem in most places to be spreading vigorously from certain definite centres, to which chance has transported a seed. Thus, *Erica ciliaris* is confined to three areas, in Cornwall, Devon, and Dorset. *E. vagans* occurs abundantly in the Lizard and

again on quite different soil in North Cornwall, so that the serpentine soil has nothing to do with its present distribution.

Chance introductions of seeds during thousands of years explain the existing peculiarities of geographical distribution in a way that no changes of sea or land or climate will do. Our alpine flora consists largely of survivors from a colder period; the rest of our flora, on the other hand, is constantly being added to by chance introductions from the nearest continental shore. That is why the Atlantic element, and the eastern element, though not consisting to any great extent of maritime plants, are confined mainly in Britain to areas within a few miles of the coast. Seeds are evidently brought from the Continent and scattered broadcast over certain coastal districts, and they grow and spread where soil and climate are suitable. But the Post-Glacial Period has been so short that the process is still incomplete, and the slow spreading inland has only as yet extended a few miles. We can still fix the point or points of introduction.

The most striking elements in the British flora, except the arctic and alpine species, have a marked coastal distribution. The plants found correspond to those of the land opposite (in which they are often inland, as well as coastal). Thus the Cornish plants and those of S.W. Ireland contain a large Pyrenean element; Norfolk plants correspond to those of the opposite shore of the North Sea; even two or three American plants are found on the coasts facing America.

All the evidence seems, therefore, to point to a steady change and increase in our flora, due to occasional introductions. These introductions are, I think, now mainly due to birds driven by exceptional gales. But herds of migrating bison, deer, and horse have played their part, especially when the Straits of Dover were much narrower or non-existent. Packs of wolves which hunted the large game, foxes, cats, and especially raptorial birds, which waited for and struck down the tired migrants, must also have assisted. Fences and the destruction of wild animals have probably rendered the process far slower than formerly; but it still goes on, as anyone can see who notes the constant occurrence of seedling oaks miles from the nearest tree.

If I am right, therefore, there is no such thing as a native plant in Britain. Our flora has been swept away like that of Krakatoa; but we have arrived at a much later stage of the re-peopling in our islands. It seems to me far more interesting to watch this process of introduction, change, and spreading than to enter into speculations as to what species shall be listed as 'natives,' 'denizens,' or 'colonists.' No such differences exist; it is all a question of degree.

Britain for several thousand years has been receiving colonists from all sources, and the process still goes on. The oldest element in our flora, the alpine, occurs on nearly all our mountains; for it once occupied the intervening areas, and it does not greatly depend on conditions of soil. The limestone, aquatic, and Lusitanian flora, on the other hand, are more recent introductions; they can never have occupied continuous areas, and their present distribution is full of singular anomalies. These three elements of our flora are steadily growing in importance, whilst the alpine element is stationary, or tends to die out.

The Chairman (Professor Weiss) then read a letter from Dr. ALFRED RUSSEL WALLACE, F.R.S., to Mr. Clement Reid, in which the following passages occur: 'I have read your paper on British plants and the Glacial Period with great interest, mainly because you support my views of the great powers of distribution of plants over the ocean, not only for a few tens of miles, but for many hundreds and even, in rare cases, thousands. I really wish you would look up and read again my discussion of the Flora of the Azores, in my "Island Life." In this case there is absolutely no doubt that the whole of its plants have been gradually introduced during the latter half of the Tertiary Period over a width of ocean of about a thousand miles by such causes as you mention, while the absence of all those genera whose seed could not have passed by those means, completes the proof. . . . But while, therefore, I quite agree with your argument as to the fact of the very large number of our species which have been so derived since the Glacial Period, I cannot accept your view that the whole has been so introduced, for several reasons. It is certain that temperature is only one of many, very many, factors that determine the distribution of species; and it is also certain that at the

southern limit of the ice-sheet the winter temperature may have been quite mild enough to support a large number of our species. In a large part of the South of England I see no reason why hundreds of species may not have lived since the pliocene, the covering of snow during the winter being a compensation for the lower temperature of the air for a portion of the time. . . .'

Dr. **Scharff** discussed the problem from a zoological point of view, dealing chiefly with the larger animals living in Ireland in present and past times. In the Irish turf, marl, and cave deposits we find various mammalian remains. The more recent deposits contain remains of the red deer (still living in Ireland). Lower down are found those of the reindeer, Irish elk, lemming, Arctic fox, hyæna, mammoth, &c. Many of these large herbivores undoubtedly existed at the same time in Ireland. There must therefore have been ample food (*i.e.*, plants) available for these creatures at that time. To all appearance the northern species such as lemming, Arctic fox, reindeer, &c., immigrated to Ireland after the animals of a more southern origin were already in the country. It is generally believed that the northern fauna and flora came south during the Glacial Period. Hence Dr. Scharff regarded the whole of the present fauna as being of preglacial or early glacial origin. It seems evident that these animals could only have reached Ireland by a land connection with Great Britain. Dr. Scharff differed from Mr. Reid in regard to the destruction of the Irish mammalian fauna; and was of opinion that the mass of the fauna survived the Glacial Period in Ireland.

Dr. **Otto Stapf** expressed his agreement with the author's views as to the effect of the glaciation of the British Isles on the flora, and the re-immigration of the bulk of the latter in post-glacial times, but combated the theory of the presence of the peculiar American, Atlantic, and limestone elements being due to chance introduction over great distances. He described the present distribution of the American and Atlantic plants in question and pointed out that there existed in both cases such gradations of discontinuity as to connect the extreme cases with cases of almost continuous areas, the former representing merely the last phase of disintegration. In the case of the Atlantic elements, many of them reach to, or so closely approach, the English Channel *viâ* the West of France, that the assumption of comparatively small climatic changes making for a milder climate, such as existed at one time after the withdrawal of the great glaciers, seems quite sufficient to explain a former more or less continuous extension of those Atlantic plant areas. There is no need to postulate a pleistocene land connection across the Bay of Biscay, nor extraordinary cases of seed dispersal by winds or birds. He finally pleaded for some action to secure the co-ordination and preservation of all records (including all the rare finds) which bear on the history of the flora of the British Isles.

Professor C. **Schroter** gave a brief account of two theories of the post-glacial history of the Swiss Flora. These are (1) the so-called 'clinical theory' of Nathorst, &c., and (2) the new theory of Brockman of the oceanic nature of the glacial climate. He then called attention to recent evidence from the Swiss Alps of the great effect of wind on plant distribution.

Mr. W. B. **Wright** called attention to the stability of the southern half of the British Isles since early glacial times, which is proved by the occurrence throughout this area and the north of France of a pre-glacial shoreline, parallel to and only a few feet above the present one. This implies that there has been little or no recent folding or faulting in this region, and shows that the oscillations in the relative level of land and sea were of a regional character. The presence of deeply submerged forests and peat beds throughout the district indicates, though it hardly proves, that a land connection existed with the continent in post-glacial times. This connection seems to be demanded for the entry of the larger mammals, which have found their way into England and Ireland since the Ice Age. Dr. Scharff stood almost alone among the scientists of Ireland in believing that any portion of that island could have harboured a temperate fauna and flora during the maximum glaciation.

The evidence as to the total extinction of all life on Krakatoa has been questioned on the ground that seeds may have been preserved in the old surface deposits beneath the mantle of ash, and subsequently exposed for growth by the rapid formation of rain gullies known to have followed the eruption.

Communications were then read from Professor P. F. **Kendall** and Dr. J. E. **Marr**, F.R.S.

Professor **Kendall** said in his letter that Mr. Reid had extended to the whole of the British Isles a generalisation he himself had ventured to apply nearly twenty years ago to the case of the Isle of Man. For the purposes of this discussion he would restate some of the salient facts regarding the latter island. It possesses a varied relief with hills ranging up to 2,034 feet. The surface presents a variety of conditions, from swamp and heath to rocky hills and narrow glens; while the geological constituents afforded a wide diversity of soil and subsoil. The hydrographic features are correspondingly varied, and the climate is remarkably equable. An island thus constituted would offer conditions favourable to the maintenance of a large flora and fauna—yet the island is remarkably poor in the number of species of plants, and the indigenous fresh water fishes, amphibia, reptiles, and mammals do not together number a dozen species.

The explanation seems clear that since the departure of the great ice-sheet, beneath which the island was completely overwhelmed, there has been no land-bridge across which terrestrial plants and vertebrates could travel. The whole fauna and flora has been introduced by chance agencies across the Irish Sea. He was of opinion that since the departure of the ice, no part of the British Isles had been connected with the continent.

Dr. J. E. **Marr** pointed out that it is generally admitted that after the Great Ice Age a period occurred which was marked by widespread steppe conditions in Europe and elsewhere. We should expect survivals of this period to exist in areas not now under steppe conditions, just as survivals of the earlier Glacial Period do so where ice and snow no longer occupy the hills all the year round.

A group of xerophytes is found growing on the heaths of the Brecklands of North Suffolk and South Norfolk, many of which are not known elsewhere in Britain. It is true that they are also found on the physically similar heaths of North Germany, but in both cases they may be survivals from the steppe period, which have lingered on in spots where the local conditions somewhat resemble those of steppes.

Professor O. **Drude** maintained that the problem could only be satisfactorily attacked by considering continental evidence (*e.g.*, from the Alps, Germany, Scandinavia, &c.), as well as that furnished by Great Britain itself. In Germany, for example, during the comparatively late 'Baltic Ice Age,' when North-West Germany was already free from ice, there existed in Saxony a curious mingling of species of various types, *e.g.*, forests of *Picea excelsa*, boreal forms such as *Ledum Linnæa*, &c., and also Atlantic species, such as *Hymenophyllum tunbridgense.* Why are these boreal species absent from the moist climate of South England, where they could well grow on the heaths? Prof. Drude answered this question by suggesting that South England was occupied, even during glacial times, by Atlantic and Lusitanian species. Although he thought many species survived, some may have been introduced in post-glacial times.

Dr. F. J. **Lewis** said that in his opinion the existence of submerged peat and also of buried forests in places where tree life is now impossible (*e g.*, the western coasts of the Outer Hebrides) point to a former much greater extent of land surface. He thought Mr. Reid had underestimated the relative changes in level of sea and land. With regard to the parallel drawn between Krakatoa and the British Isles, the conditions were so different, that no reliable comparison could be made between re-immigration across a tropical sea, and the same process across a strait in cool temperate latitudes.

Dr. C. H. **Ostenfeld** agreed with Mr. Reid that no temperate species survived the Glacial Period in Britain. The importance of 'Nunataks' (on which plants may have survived) is probably overestimated: it is very difficult to produce conclusive evidence as to whether a mountain summit has, or has not, been glaciated. He was of opinion that the present flora of Britain originated somewhat as follows: (1) The arctic-alpine species survived the glacial period, mainly in the South of England; (2) the bulk of the flora crossed from the continent by means of a land connection; and (3) some few species (with small

seeds or edible fruits) belonging to the Atlantic, Lusitanian, and American elements, arrived by chance, and certain salt-marsh species by ocean currents.

Mr. E. A. N. Arber expressed the opinion that the British alpines did not come from the Arctic regions at all. The original home of the great majority of British and European alpines was northern Asia, and the path of their migration was east to west, rather than north to south. He accepted the theory upheld by some geologists that land connections existed between Great Britain and Ireland, and also between England and France, both before and after the main period of glaciation.

Dr. C. E. Moss said it was a mistake to concentrate attention on the local Lusitanian species of West Ireland and the south-west peninsula of England. These plants are connected by many intermediate ones with certain other Atlantic species which, so far as the British Isles are concerned, are limited to the southern and eastern coasts of England. *Limonium reticulatum*, *Suæda fruticosa*, *Salicornia perennis*, &c., are examples of such species. It seems probable that they migrated from South Europe along the west coast of France to the south-east of England, where they find their northern limits. No land connections, no casual dispersal by wind or birds are needed to account for the British distribution of these species; for, being halophytes, their seeds are doubtless capable of being carried by ocean drifts. The latter, having an easterly trend, may account for the absence of these species from the west of the British Isles. The distribution of these species is just as remarkable as that of the Lusitanian plants, which belong to the same distributional type.

Mr. G. Claridge Druce said he hesitated to accept the theory of the supposed post-glacial land connection as an explanation of the occurrence of the Lusitanian element in the Irish flora. The presence of the remains of the mammoth and hyæna in post-glacial deposits (if indeed they were not pre-glacial), was not more remarkable than the absence of the viper and the mole from the Irish fauna. Nor had he heard from the upholders of this theory any sufficient explanation of the great diminution of species in Ireland as compared with England. There was no doubt that many plants could be widely dispersed by birds and wind. As recent evidence of this, he cited the occurrence of *Scirpus maritimus* in Berkshire, of *S. Tabernæmontana* in Bucks and Oxon; and the extraordinarily rapid spread of *Crepis taraxacifolia* over midland England in the last twenty years.

Mr. Clement Reid then replied. He said: The wide range of the discussion and the late hour allow no time to deal with the various questions that have been raised; I would like, however, to return to the two main factors that dominate the situation. If I am right, and in this I am only voicing the opinion of all geologists who have studied the question, the glaciation and cold were so intense that it was impossible for any of the higher animals or plants to have survived in the greater part of Britain. In the South of England some Arctic and North Temperate forms lingered; but the surrounding sea was far too cold for much else.

The second factor is the extent of the connection with the Continent in post-glacial times As to this, we cannot speak with absolute certainty; but all the big rivers of England cut their post-glacial channels to about 90 feet below the present sea-level, and the Cornish rivers, which flow direct into the Atlantic, cut to about the same depth. This proves that they all had reached a definite base-level, below which they could not cut, and this base apparently must be the lowest sea-level of post-glacial times. For this reason my map shows no connection with the Continent, except near the Straits of Dover and across the southern half of the North Sea.

The Irish peat-bog mammals referred to by Dr. Scharff are all good swimmers, even the pig, and could quite well have crossed a narrow strait. The hyæna of the caves belongs to an older period than that under discussion.

TUESDAY, SEPTEMBER 5.

The following Paper was read :—

The Balance-sheet of a Plant. *By* Dr. FRANCIS DARWIN, *F.R.S.*

Discussion on the Principles of Constructing Phyto-geographical Maps.

Dr. C. E. Moss, who opened the discussion, briefly traced the history of the recently issued British vegetation maps. Those of Edinburgh and of Northern Perthshire, by the late Robert Smith, were the first to be published; and these were a direct result of the inspiration which R. Smith received from Professor Ch. Flahault, of Montpellier, who had previously published a vegetation map of a portion of the South of France. Vegetation maps by Professor O. Drude, of Dresden, and of Professor C. Schroter, of Zurich, were published about the same time as that by Flahault; and since then many had been published by Swiss, Austrian, and British botanists.

The opener concluded his remarks by summarising the uses of vegetation maps. In brief, vegetation maps are just as useful to the botanist and to the nation as geological maps. Yet whilst geological maps are prepared and published by a Government Department, the preparation of vegetation maps is left to private individuals, who have no definite means of obtaining publication of their work. At the present moment, there are as many completed British vegetation maps which cannot be published owing to lack of funds as there are of such published maps. The time is approaching when it will be necessary to consider whether or not the preparation and publication of British vegetation maps should be placed on precisely the same footing as the preparation and publication of geological maps.

The following also contributed to the discussion : —

Prof. C. Schroter (who exhibited a fine collection of phyto-geographical maps), Prof. O. Drude, Mr. A. G. Tansley, and Dr. E. Rubel.

The following Papers were then read :—

1. *The Water-content of Acidic Peats.* *By* W. B. CRUMP, *M.A.*

Recent ecological researches all emphasise the importance of edaphic factors in determining the distribution of plant associations, and the complete lack of exact data based upon quantitative experimental work. While the nature of the soil and the richness or poverty of the soil-water in nutrient salts are factors of primary importance, the water-content would seem to be of equal importance. As regards this soil-water it is recognised that some of it, possibly much of it in acidic or saline soils, is not available to plants, so that the determination of the available, or what Schimper has termed the physiological, water is also desirable. The last point is considered in another paper; the other factors are eliminated by selecting a series of habitats exclusively on siliceous rocks with the soil-water deficient in soluble salts, but always more or less acidic through the presence of humus acids. As the alkaline peats differ in all these respects and support totally different vegetation, their consideration is reserved.

The peats examined were all obtained on the moorlands of the Southern Pennines, and mostly in the neighbourhood of Halifax. The sample was selected from the zone of active root absorption, and if not apparently homogeneous it was divided into layers. It was taken during dry weather—never within a few days of any rainfall—with the purpose of obtaining the minimum value. The water-content is exclusively the water that evaporates when the peat is exposed to the air at or about 15° C., and the results are expressed in terms of such air-dry peat. The peat was then oven-dried and subjected to combustion to determine the humus and mineral residue. This not only graded the peats, but eventually furnished the solution of the problem. Without a

knowledge of the humus-content the water-content was meaningless, and the analyses widely discordant. But the ratio $\frac{\text{Water-Content}}{\text{Humus-Content}}$ reduces them to order. This is most evident in dealing with successive layers of the same section, *e.g.*, a peat containing 170 per cent. of water lies immediately above a sandy subpeat with only 30 per cent., and the fine rootlets of bilberry penetrate both. But the ratio is practically the same for each, viz., 3·0 and 2·9. So, again, the ratio will reveal superficial drying by its low value when the actual water-content may be very high.

The ratio $\frac{\text{Humus}}{\text{Mineral}}$ is also a convenient way of expressing the humus-content of the peat.

Conclusions.

1. The Pennine peats form an homologous series, each homologue being sufficiently distinguished by its water- and humus-contents to separate it from other members of the series.

2. These homologues correspond to the following recognised plant-associations:-

I. *Pure Eriophorum Moor on deep peat* (19 analyses).—Characters: Peat very pure and uniform; water, 300-600 per cent.; humus, above 80 per cent.; ash, purely vegetable, very low, under 2 per cent.; water coefficient, 6·0.

II. *Rocky Edge of Eriophorum Moor* (4 analyses).—*Vaccinium Myrtillus* or Empetrum dominant. Characters: Peat still very pure, not so deep; water, 250-300 per cent.; humus and ash, as before; water coefficient, 3·0.

III. *Transitional Eriophorum Moor* (13 analyses).—A mixed association of Eriophorum, *Vaccinium Myrtillus*, Pteris, Calluna, Molinia, &c. Characters, peat moderately deep, still pure, but not so uniform and comparatively dry; water, 100-200 per cent. (average 160 per cent.); humus, 50-80 per cent. (average 64 per cent.); mineral residue now containing rock débris, 10-40 per cent.; water coefficient, 2·6.

IV. *Calluna Moor* (28 analyses).—Characters, peat shallow, impure. Two types may be distinguished: (*a*) wet, with *Erica tetralix* present; water, 60-100 per cent. (average 90 per cent.); humus, 20-50 per cent.; water coefficient, above 2·5 (average 3·3); (*b*) typical, water, average 85 per cent.; water coefficient, 2·0-2·8 (average 2·3). The coarse sandy subpeat, with quartz grains, contains an average of only 25 per cent. water, but water coefficient remains between 2·5 and 3·5.

V. *Molinia Moor* (9 analyses).—This presents the only contradiction of current views both as regards water- and humus-contents, for the peat is quite as pure as that of the Calluna moor, but distinctly drier. Characters, deeper than Calluna peat, but never pure. Water, 30-80 per cent., average 56 per cent.; humus, about 30 per cent.; water coefficient, under 2 (average 1·93).

3. The series constitutes an edaphic formation.

NOTE.—The consideration of *Heath Pasture* is omitted.

2. *The Wilting of Moorland Plants.* *By* W. B. CRUMP, *M.A.*

The purpose of the investigation, carried out in the summer of last year, is to arrive at the physiological water-content of moorland soils. This is done by determining the water still remaining in the soil when wilting definitely sets in. A preliminary set of experiments made in 1906 had already given fairly satisfactory results and a knowledge of the main difficulties and precautions; but they were neither numerous enough nor started sufficiently early in the season to justify publication. The initial difficulty in the case of moorland plants is to decide when wilting occurs. The indications common in mesophytes, such as flaccidity, drooping or total collapse, are absent; withering creeps on so gradually that one is at a loss to decide where to draw the line. Experience, gained by the sacrifice of some of the plants, furnishes a clue in some cases; and in several species, notably *Molinia* and *Eriophorum angustifolium*, a more precise test was found in the rolling or folding of the leaves.

About sixty specimens were obtained and established in pots, ranging from 4½ to 7½ inches, during March and April 1910, before the renewal of growth had set in. At the end of June about forty were growing satisfactorily and these were protected from rain by a light screen from July onwards. When it was apparent that wilting had set in, the peat or soil was sampled from among the roots and air-dried. The table gives a digest of the results obtained, with the exception of such as are not satisfactory from over drying or other causes. The humus and water remaining in the soil are expressed in terms of the air-dry soil. The further loss at 100° is not entered.

The ratio water/humus is a better index of the state of the soil than is the water-content, for it shows less individual fluctuation. Comparison with its normal value shows the following approximate relations to exist:—

One-third of the water-content of peat is non-available in the case of . . .	*Erica Tetralix Molinia, Pteris.*
One-quarter . .	*Deschampsia, Nardus.*
One-fifth . . .	*Calluna*, in pure peat.
One-sixth . . .	*Vaccinium Myrtillus, Agrostis.*
One-seventh . .	*Eriophorum* spp., *Calluna*, in sandy peat.
One-ninth . . .	*Vaccinium Vitis-Idæa.*

The analyses also show the influence of the soil. Though not numerous from this point of view, the water/humus ratio is highest in the case of a heavy loam, and higher for a pure peat than a sandy peat. Conversely, the time taken to produce wilting is longest with a sand and sandy peat, and shortest in the case of loam.

Water content of Air-dry Soils when Wilting sets in.

Plant	No. of Analyses	Period of Drought, Weeks	Soil	Humus, per cent.	Water non-available, per cent		Water/Humus	
					Mean	Range	Mean	Range
Eriophorum angustifolium . . .	9	3	peat	72–45	52	68–32	0·81	1·0–0·56
E. vaginatum . .	3	3	,,	72–54	62	66–41	0·88	1·0–0·7
Vaccinium Myrtillus	3	5	,,	72–64	35	41–32	0·49	0·56–0·4
V. Vitis-Idæa . .	4	5	,,	84–52	21	28–14	0·30	0·4–0·24
Calluna vulgaris .	5	2–3	,,	78–64	27	34–22	0·47	0·6–0·38
	5		sandy peat	35–4		12–1	0·32	0·35–0·27
	2		sand loam	11–10	5·8	6–5·5	0·53	0·53–0·52
Erica Tetralix[1] .	3	2	peat	58–21		75–22	1·2	1·3–1·0
Pteris aquilina . .	2	3(?)	sandy peat	28–18	20	24–17	0·9	0·93–0·86
Molinia cærulea .	4	2½	peat	66–58	39	47–29	0·6	0·7–0·5
Deschampsia flexuosa	2	3	,,	80–74	54	63–45	0·7	0·8–0·6
	1	3	sandy peat	34	13		0·4	
	1	3	sand	4·5	1·4		0·3	
	1	2	loam	9	13		1·4	
Nardus stricta . .	1	3	peat	70	47		0·66	
Agrostis vulgaris .	1		sand	5·5	2·0		0·36	

[1] Over-dried.

WEDNESDAY, SEPTEMBER 6.

The following Papers and Reports were read:—

1. *On the Presence of Sugar in the Tissues of Laminaria.* By S. MANGHAM.

Laminaria digitata and *L. saccharina* have been examined for sugars at various times of the year by means of Senft's method of forming osazones.

The material used was either sent in sea-water from Aberystwyth by Professor Yapp, and examined as soon as received at Cambridge, or was gathered at the end of March at Port Erin, Isle of Man, and investigated at once at the marine biological laboratory.

Observations were made upon sections cut from the stipe, the region of new

growth, and from the lamina. Crystalline osazones have been found in the cortical cells, the sieve-tubes, and the hyphæ in both species, and particularly at the time of formation of the new lamina in *L. digitata.* Some of the crystals in the latter plant very closely resemble those yielded by Maltose, but their exact identity is at present unknown.

This production of osazones in the hyphæ and in the sieve-tubes after treatment with Senft's reagent affords experimental evidence in support of the conducting and storing function hitherto assigned to these elements mainly on account of their structure.

2. *The Structure and Function of the Root-nodules of* Myrica Gale.

By Professor W. B. BOTTOMLEY, *M.A.*

The root-nodules of *Myrica Gale* arise as modifications of normal lateral roots which by branching form the characteristic 'clusters' covered with rootlets growing out through the end of each nodule or branch. The branching is due to the outgrowth of lateral roots, and not to dichotomy of the apex of the primary nodule, as in the root-nodules of Cycas, Alnus, and Elæagnus.

In transverse section a young nodule shows a central tetrarch vascular cylinder surrounded by an endodermis of cells filled with oil drops. The cortical tissue contains (*a*) numerous 'bacterial cells,' in which the bacteria can be seen by treatment with Kiskalt's Amyl Gram stain; and (*b*) cells filled with oil drops. Towards the apex of the nodule 'infection threads' can be seen passing from cell to cell, and the whole nodule is protected on the outside by two or three layers of cork cells.

When the growth of the nodule is nearly complete the end of the stele, surrounded by a few cortical cells, grows on and out from the apex of the nodule, and forms a thin rootlet. Around the end of the nodule usually three (occasionally only two) branches arise as lateral swellings which grow and repeat exactly the structure of the primary nodule, with a rootlet growing out from the apex of each branch. By repeated branching the typical 'cluster' nodules are formed.

Pure cultures of the bacteria from the 'bacterial cells' show small rod-like organisms identical in appearance and structure with *Pseudomonas radicicola*, the organism found in all leguminous nodules, and give a definite fixation of nitrogen when grown in Erlenmeyer flasks:—

Control flask	0·53 mgr. N. per 100 c.c.
Inoculated flask	2·58 „ „ „ „

Young Myrica plants grown in pots in soil deficient in nitrogen flourished well if possessing nodules, if without nodules on their roots they soon died.

Evidently the root-nodules of Myrica are concerned with the assimilation of atmospheric nitrogen, as are the root-nodules of Cycas, Alnus, Elæagnus, and Podocarpus.

3. *Some Effects of Bacteriotoxins on the Germination and Growth of Plants.*

By Professor W. B. BOTTOMLEY *M.A.*

An aqueous extract of well-rotted manure or fertile soil, obtained by treating 100 grm. of manure or soil with 500 c.c. of isotonic salt solution and filtering through a Pukall filter, has an injurious effect on the germination of seeds and their further growth in sand, even when supplied with normal food-solution. This inhibitory effect of the extract can be destroyed by boiling. The harmful effect is due to the presence of certain bacteriotoxins, probably of the nature of toxalbumoses, formed by the activities of the decomposition and denitrifying bacteria in the manure or the soil, and by heating the toxic influence is destroyed and the substance rendered available as a nutrient.

Experiments with germinating seeds of mustard, turnip, tares, and barley give support to this theory. Seeds germinated in pots containing sand moistened with (*a*) distilled water, (*b*) saline solution, (*c*) raw extract, (*d*) boiled extract showed that the raw extract almost prevented germination and the subsequent

growth was very feeble, whilst the boiled extract, although slightly retarding germination at first, soon appeared to benefit the seedlings which became stronger and healthier than those grown without extract.

The extract was also found to have a marked influence on the growth of certain soil organisms. It stimulated the growth of denitrifying bacteria, and inhibited the growth of the nitrogen fixing bacteria. Both these effects were destroyed by boiling the extract.

4. *The Polyphyletic Origin of Cornaceæ.* *By* A. S. HORNE, *B.Sc.*, *F.G.S.*

This conception of the phylogeny of Cornaceæ has resulted from a detailed study of the structure of the flower of several genera of Cornaceæ and a comparative study of the effects brought about by progressive sterilisation and reduction in the ovary of the Caprifoliaceæ, Hamamelidaceæ, and Araliaceæ.

A series may be found among Caprifoliaceæ showing every intermediate stage in reduction between ovaries of the *Leycesteria* type (double rows of ovules in each chamber) and uniovular ovaries (*Viburnum*). The changes exemplified by this series are accompanied by alterations in the vascular structure of the ovary (*Viburnum*) and by modifications in the vascular supply to the ovule (*Symphoricarpus*). Progressive reduction trends towards the uniovular condition, but each genus pursues an independent course of development towards this condition (*Lonicera*, *Symphoricarpus*, *Viburnum*, *Sambucus*).

The terminal ovules of *Aralia*, *Davidia*, and *Viburnum* have had, in each case, a separate evolutionary history.

The flowers of Cornaceæ possess certain general resemblances, such as, for instance, with respect to polypetaly, epigyny, &c., whilst the ovaries or loculi of a number of genera are uniovular with terminal ovules. They possess, however, peculiarities with regard to (*a*) structure of the ovary (*Cornus*); (*b*) vascular structure of the ovary (*Garrya*); (*c*) vascular supply to the ovule (*Griselinia*); (*d*) form of ovule (*Davidia*); (*e*) structure of nucellus (*Aucuba*); (*f*) vascular rudiments (*Aucuba*).

It is suggested that these peculiarities indicate different origins. The general resemblances in structure do not appear to be of any considerable value in establishing *close* relationships within the order, but, on the other hand, are to be regarded as striking parallelisms brought about as a result of the operation of similar evolutionary processes upon distantly related forms.

5. *The Chromosomes of the Hybrid* Primula kewensis. *By* Miss L. DIGBY.

Much attention has of late been directed upon the cytology of hybrids, for the behaviour of the nuclei of offspring derived from the union of unlike parental germ cells may one day throw some light on the great unsolved problem of heredity.

As the hybrid, *P. kewensis*, has so interesting a horticultural history, it seemed that a record of its cytology might be of value. The investigation has proved both easy and productive, as the nuclear phases are clear and well defined, and the chromosome numbers are low.

The original *P. kewensis* plant appeared among a pure batch of *P. floribunda* seedlings at Kew in 1899. It was noticeable on account of its more robust growth, and its different foliage, and was believed to be a cross between *P. floribunda* and *P. verticillata*. This supposition was verified the following year, when the cross was made artificially, and resulted in a good proportion of *P. kewensis* seedlings. The hybrid, *P. kewensis*, proved to be sterile, and bore only 'thrum-eyed' flowers.

Some years afterwards in Messrs. Veitch's nurseries a single 'pin-eyed' flower was noticed. This was promptly fertilised, good seed was set, and the resultant plants possessed both 'thrum-eyed' and 'pin-eyed' flowers, and were fertile. Thus the whole fertile, or seedling, stock of *P. kewensis* owes its origin to the one 'pin-eyed' flower on the sterile, or type stock of *P. kewensis*. Messrs. Veitch have since, by selection, produced the variety, *P. kewensis farinosa*, which accentuates the mealiness of the parent, *P. verticillata*.

As regards the numbers of the chromosomes in the various generations, the parents of *P. kewensis* (sterile) have identically the same number of chromosomes, and, as might be expected, this number is repeated in the hybrid. Thus *P. floribunda*, *P. verticillata*, and *P. kewensis* (sterile) all have 18 (2 x) and 9 (x) chromosomes. The surprising phenomenon occurs in the seedling, *P. kewensis*, for there, instead of the familiar 18 (2 x) and 9 (x) chromosomes, there are 36 (2 x) and 18 (x) chromosomes.

By some means either at, or subsequent to, the fertilisation of the 'pin flower' on the sterile stock the number of chromosomes has been duplicated. This doubled number is continued throughout the generations of the fertile *P. kewensis*, and is also characteristic of the variety, *P. kewensis farinosa*.

This increase in the number of chromosomes cannot be accounted for by apogamy. The divisions of the embryo sac mother nuclei of both the sterile and of the fertile forms are normal, and in the one case 9 (x) chromosomes, and in the other 18 (x) chromosomes are to be seen at meiosis, while in the surrounding tissue there are correspondingly 18 (2 x) and 36 (2 x) chromosomes.

The doubled number of chromosomes has since reappeared in a cross made in 1910 by Coutts, the foreman, at Kew, between *P. verticillata* and *P. floribunda* var. *isabellina*. The resulting hybrids not only resemble *P. kewensis farinosa* in their external features, but also possess 36 (2 x) chromosomes.

This remarkable sudden duplication of chromosomes has its counterpart in the Œnotheras. *Œ. Lamarckiana* has 14 (2 x) and (7 x) chromosomes, while *Œ. gigas*, which mutated from *Œ. Lamarckiana*, has 28 (2 x) and 14 (x) chromosomes. Like the fertile *P. kewensis*, *Œ. gigas* has again arisen from other sources - once as a hybrid, and once from a pure strain of *Œ. sublinervis*. In the Œnotheras, as there is no evidence of the addition of new unit characters, the doubling of the chromosomes is believed to be brought about by longitudinal fission. In the Primulas the phenomenon is apparently associated with the change from the sterile to the fertile condition.

One other interesting fact has emanated from the 1910 Primula hybrids. *P. floribunda* var. *isabellina*, with its 18 (2 x) and 9 (x) chromosomes, when crossed with *P. kewensis*, seedling form, with its 36 (2 x) and 18 (x) chromosomes, has offspring which resemble the seed parent, *P. floribunda* var. *isabellina*, both in external characters and in the number of the chromosomes. By some regulating process the sum of $9\,(x)+18\,(x)=18\,(2x)$.

Again, an analogy is to be found in the Œnotheras. *Œ. lata*, 14 (x) and 7 (x) chromosomes, crossed with *Œ. gigas*, 28 (2 x) and 14 (x) chromosomes, results in a hybrid with 21 (2 x) chromosomes. According to Geerts, at meiosis, the seven homologous chromosomes, derived from either parent, pair, the seven supernumerary unpaired chromosomes disintegrate. In this way the x number of chromosomes in the hybrid is reduced to that of the parent which possesses the lowest number

Such are the facts concerning the chromosomes in the parents of the hybrid *P. kewensis*, in the hybrid itself, and in the ensuing generations. A detailed and comparative account of the cytology of this series of Primulas will be published shortly.

6. *On the Flora of Shetland, with some reference to its Ecology*
By W. West.

7. *The Occurrence of* Oidium Enonymi-Japonicæ *in Southern England.*
By Sir Daniel Morris, *K.C.M.G.*

8. *Report on the Structure of Fossil Plants.*—See Reports, p. 176.

9. *Report on the Experimental Study of Heredity.*—See Reports, p. 176.

10. *Report on the Survey of Clare Island.*—See Reports, p. 176.

11. *Report on the Registration of Botanical Photographs.* See Reports, p. 177.

12. *Interim Report on the Promotion of the Study of the Plant Life of the British Islands, and the preparation of the Materials for a National Flora.*

SUB-SECTION OF AGRICULTURE.

CHAIRMAN.—W. BATESON, M.A., F.R.S.

THURSDAY, AUGUST 31.

The Chairman delivered the following Address:—

THE invitation to preside over the Agricultural Sub-Section on this occasion naturally gave me great pleasure, but after accepting it I have felt embarrassment in a considerable degree. The motto of the great Society which has been responsible for so much progress in agricultural affairs in this country very clearly expresses the subject of our deliberations in the words 'Practice with Science,' and to be competent to address you, a man should be well conversant with both. But even if agriculture is allowed to include horticulture, as may perhaps be generally conceded, I am sadly conscious that my special qualifications are much weaker than you have a right to demand of a President.

The aspects of agriculture from which it offers hopeful lines for scientific attack are, in the main, three: Physiological, Pathological, and Genetic. All are closely interrelated, and for successful dealing with the problems of any one of these departments of research, knowledge of the results attained in the others is now almost indispensable. I myself can claim personal acquaintance with the third or genetic group alone, and therefore in considering how science is to be applied to the practical operations of agriculture, I must necessarily choose it as the more special subject of this address. I know very well that wider experience of those other branches of agricultural science or practical agriculture would give to my remarks a weight to which they cannot now pretend.

Before, however, proceeding to these topics of special consideration, I have thought it not unfitting to say something of a more general nature as to the scope of an applied science, such as that to which we here are devoted. We are witnessing a very remarkable outburst of activity in the promotion of science in its application to agriculture. Public bodies distributed throughout this country and our possessions are organising various enterprises with that object. Agricultural research is now everywhere admitted a proper subject for University support and direction.

With the institution of the Development Grant a national subsidy is provided on a considerable scale in England for the first time.

At such a moment the scope of this applied science and the conditions under which it may most successfully be advanced are prominent matters of consideration in the minds of most of us. We hope great things from these new ventures. We are, however, by no means the first to embark upon them. Many of the other great nations have already made enormous efforts in the same direction. We have their experience for a guide.

Now, it is not in dispute that wherever agricultural science has been properly organised valuable results have been attained, some of very high importance indeed; yet with full appreciation of these achievements, it is possible to ask whether the whole outcome might not have been greater still. In the course of recent years I have come a good deal into contact with those who in various countries are taking part in such work, and I have been struck with the unanimity that they have shown in their comments on the conditions imposed upon them. Those who receive large numbers of agriculture bulletins purporting to give the results of practical trials and researches will, I feel sure, agree with me that with certain notable exceptions they form on the whole dull reading. True they are in many cases written for farmers and growers in special districts, rather than for the general scientific reader, but I have sometimes asked myself whether those farmers get much more out of this literature than I do. I doubt it greatly. Nevertheless, to the production of these things much labour and expense have been devoted. I am sure, and I believe that most of those engaged in those productions themselves feel, that the effort might have been much better applied elsewhere. Work of this unnecessary kind is done, of course, to satisfy a public opinion which is supposed to demand rapid returns for outlay, and to prefer immediate apparent results, however trivial, to the long delay which is the almost inevitable accompaniment of any serious production. For my own part, I greatly doubt whether in this estimate present public opinion has been rightly gauged. Enlightenment as to the objects, methods, and conditions of scientific research is proceeding at a rapid rate. I am quite sure, for example, that no organisation of agricultural research now to be inaugurated under the Development Commission will be subjected to the conditions laid down in 1887 when the Experimental Stations of the United States were established. For them it is decreed in section 4 of the Act of Establishment:—

> 'That bulletins or reports of progress shall be published at said stations at least once in three months, one copy of which shall be sent to each newspaper in the States or Territories in which they are respectively located, and to such individuals actually engaged in farming as may request the same and as far as the means of the station will permit.'

It would be difficult to draft a condition more unfavourable to the primary purpose of the Act, which was 'to conduct original researches or verify experiments on the physiology of plants and animals.' I can scarcely suppose the most prolific discoverer should be invited to deliver himself more than once a year. Not only does such a rule compel premature publication—that nuisance of modern scientific life—but it puts the investigator into a wrong attitude towards his work. He will do best if he forget the public and the newspaper of his State or Territory for long periods, and should only return to them when, after repeated verification, he is quite certain he has something to report.

In this I am sure the best scientific opinion of all countries would be agreed. If it is true that the public really demand continual scraps of results, and cannot trust the investigators to pursue research in a reasonable way, then the public should be plainly given to understand that the time for inaugurating researches in the public's name has not arrived. Men of science have in some degree themselves to blame if the outer world has been in any mistake on these points. It cannot be too widely known that in all sciences, whether pure or applied, research is nearly always a very slow process, uncertain in production, and full of disappointments. This is true, even in the new industries, chemical and electrical, for instance, where the whole industry has been built up from the beginning on a basis developed entirely by scientific method and by the accumulation of precise knowledge. Much more must any material advance be slow in the case of an ancient art like agriculture, where practice represents the casual experience of untold ages and accurate investigation is of yesterday. Problems moreover relating to unorganised matter are in their nature simpler than those concerned with the properties of living things, a region in which accurate knowledge is more difficult to attain. Here the research of the present day can aspire no higher than to lay the foundation on which the following generations will build. When this is realised it will at once be perceived that both those who are engaged in agricultural research and those who are charged with the

supervision and control of these researches must be prepared to exercise a large measure of patience.

The applicable science must be created before it can be applied. It is with the discovery and development of such science that agricultural research will for long enough best occupy its energies. Sometimes, truly, there come moments when a series of obvious improvements in practice can at once be introduced, but this happens only when the penetrative genius of a Pasteur or a Mendel has worked out the way into a new region of knowledge, and returns with a treasure that all can use. Given the knowledge it will soon enough become applied.

I am not advocating work in the clouds. In all that is attempted we must stick near to the facts. Though the methods of research and of thought must be strict and academic, it is in the farm and the garden that they must be applied. If inspiration is to be found anywhere it will be there. The investigator will do well to work

'As if his highest plot
To plant the bergamot.'

It is only in the closest familiarity with phenomena that we can attain to that perception of their orderly relations, which is the beginning of discovery.

To the creation of applicable science the very highest gifts and training are well devoted. In a foreign country an eminent man of science was speaking to me of a common friend, and he said that as our friend's qualifications were not of the first rank he would have to join the agricultural side of the university. I have heard remarks of similar disparagement at home. Now, whether from the standpoint of agriculture or pure science, I can imagine no policy more stupid and shortsighted.

The man who devotes his life to applied science should be made to feel that he is in the main stream of scientific progress. If he is not, both his work and science at large will suffer. The opportunities of discovery are so few that we cannot afford to miss any, and it is to the man of trained mind who is in contact with the phenomena of a great applied science that such opportunities are most often given. Through his hands pass precious material, the outcome sometimes of years of effort and design. To tell him that he must not pursue that inquiry further because he cannot foresee a direct and immediate application of the knowledge he would acquire, is, I believe almost always, a course detrimental to the real interests of the applied science. I could name specific instances where in other countries thoroughly competent and zealous investigators have by the short-sightedness of superior officials been thus debarred from following to their conclusion researches of great value and novelty.

In this country where the Development Commission will presumably for many years be the main instigator and controller of agricultural research, the constitution of the Advisory Board, on which Science is largely represented, forms a guarantee that broader counsels will prevail, and it is to be hoped that not merely this inception of the work, but its future administration also will be guided in the same spirit. So long as a train of inquiry continues to extend, and new knowledge, that most precious commodity, is coming in, the enterprise will not be in vain and it will be usually worth while to pursue it.

The relative value of the different parts of knowledge in their application to industry is almost impossible to estimate, and a line of work should not be abandoned until it leads to a dead end, or is lost in a desert of detail.

We have, not only abroad, but also happily in this country, several private firms engaged in various industries—I may mention especially metallurgy, pharmacy, and brewing—who have set an admirable example in this matter, instituting researches of a costly and elaborate nature, practically unlimited in scope, connected with the subjects of their several activities, conscious that it is only by men in close touch with the operations of the industry that the discoveries can be made, and well assured that they themselves will not go unrewarded.

Let us on our part beware of giving false hopes. We know no hæmony 'of sovran use against all enchantments, mildew blast, or damp.' Those who are wise among us do not even seek it yet. Why should we not take the farmer and gardener into our fullest confidence and tell them this? I read lately a newspaper interview with a fruit-farmer who was being questioned as to the success of his undertaking, and spoke of the pests and difficulties with which he

had had to contend. He was asked whether the Board of Agriculture and the scientific authorities were not able to help him. He replied that they had done what they could, that they had recommended first one thing and then another, and he had formed the opinion that they were only in an experimental stage. He was perfectly right, and he would hardly have been wrong had he said that in these things science is only approaching the experimental stage. This should be notorious. There is nothing to extenuate. To affect otherwise would be unworthy of the dignity of science.

Those who have the means of informing the public mind on the state of agricultural science should make clear that though something can be done to help the practical man already, the chief realisation of the hopes of that science is still very far away, and that it can only be reached by long and strenuous effort, expended in many various directions, most of which must seem to the uninitiated mere profitless wandering. So only will the confidence of the laity be permanently assured towards research.

Nowhere is the need for wide views of our problems more evident than in the study of plant-diseases. Hitherto this side of agriculture and of horticulture, though full of possibilities for the introduction of scientific method, has been examined only in the crudest and most empirical fashion. To name the disease, to burn the affected plants, and to ply the crop with all the sprays and washes in succession ought not to be regarded as the utmost that science can attempt. There is at the present time hardly any comprehensive study of the morbid physiology of plants comparable with that which has been so greatly developed in application to animals. The nature of the resistance to disease characteristic of so many varieties, and the modes by which it may be ensured, offers a most attractive field for research, but it is one in which the advance must be made by the development of pure science, and those who engage in it must be prepared for a long period of labour without ostensible practical results. It has seemed to me that the most likely method of attack is here, as often, an indirect one. We should probably do best if we left the direct and special needs of agriculture for a time out of account, and enlisted the services of pathologists trained in the study of disease as it affects man and animals, a science already developed and far advanced towards success. Such a man, if he were to devote himself to the investigation of the same problems in the case of plants could, I am convinced, make discoveries which would not merely advance the theory of disease-resistance in general very greatly, but would much promote the invention of rational and successful treatment.

As regards the application of Genetics to practice, the case is not very different. When I go to the Temple Show or to a great exhibition of live-stock my first feeling is one of admiration and deep humility. Where all is so splendidly done and results so imposing are already attained, is it not mere impertinence to suppose that any advice we are able to give is likely to be of value?

But as soon as one enters into conversation with breeders, one finds that almost all have before them some ideal to which they have not yet attained, operations to perform that they would fain do with greater ease and certainty, and that, as a matter of fact, they *are* looking to scientific research as a possible source of the greater knowledge which they require. Can we, without presumption, declare that genetic science is now able to assist these inquirers? In certain selected cases it undoubtedly can—and I will say, moreover, that if the practical men and we students could combine our respective experiences into one head, these cases would already be numerous. On the other hand, it is equally clear that in a great range of examples practice is so far ahead that science can scarcely hope in finite time even to represent what has been done, still less to better the performance. We cannot hope to improve the Southdown sheep for its own districts, to take a second off the trotting record, to increase the flavour of the muscat of Alexandria, or to excel the orange and pink of the rose Juliet. Nothing that we know could have made it easier to produce the Rambler roses, or even to evoke the latest novelties in sweet peas, though it may be claimed that the genetic system of the sweet pea is, as things go, fairly well understood. To do any of these things would require a control of events so lawless and rare that for ages they must probably remain classed as accidents. On the other hand, the modes by which combinations can be made, and by which new forms

can be fixed, are through Mendèlian analysis and the recent developments of genetic science now reasonably clear, and with that knowledge much of the breeder's work is greatly simplified. This part of the subject is so well understood that I need scarcely do more than allude to it.

A simple and interesting example is furnished by the work which Mr. H. M. Leake is carrying out in the case of cotton in India. The cottons of fine quality grown in India are monopodial in habit, and are consequently late in flowering. In the United Provinces a comparatively early-flowering form is required, as otherwise there is not time for the fruits to ripen. The early varieties are sympodial in habit, and the primary apex does not become a flower. Hitherto no sympodial form with cotton of high quality has existed, but Mr. Leake has now made the combination needed, and has fixed a variety with high-class cotton and the sympodial habit, which is suitable for cultivation in the United Provinces. Until genetic physiology was developed by Mendelian analysis, it is safe to say that a practical achievement of this kind could not have been made with rapidity or certainty. The research was planned on broad lines. In the course of it much light was obtained on the genetics of cotton, and features of interest were discovered which considerably advance our knowledge of heredity in several important respects. This work forms an admirable illustration of that simultaneous progress both towards the solution of a complex physiological problem and also towards the successful attainment of an economic object which should be the constant aim of agricultural research.

Necessarily it follows that such assistance as genetics can at present give is applicable more to the case of plants and animals which can be treated as annuals than to creatures of slower generation. Yet this already is a large area of operations. One of the greatest advances to be claimed for the work is that it should induce raisers of seed crops especially to take more hopeful views of their absolute purification than have hitherto prevailed. It is at present accepted as part of the natural perversity of things that most high-class seed crops must throw 'rogues,' or that at the best the elimination of these waste plants can only be attained by great labour extended over a vast period of time. Conceivably that view is correct, but no one acquainted with modern genetic science can believe it without most cogent proof. Far more probably we should regard these rogues either as the product of a few definite individuals in the crop, or even as chance impurities brought in by accidental mixture. In either case they can presumably be got rid of. I may even go further and express a doubt whether that degeneration which is vaguely supposed to be attendant on all seed crops is a physiological reality. Degeneration may perhaps affect plants like the potato which are continually multiplied asexually, though the fact has never been proved satisfactorily. Moreover it is not in question that races of plants taken into unsuitable climates do degenerate rapidly from uncertain causes, but that is quite another matter.

The first question is to determine whether a given rogue has in it any factor which is *dominant* to the corresponding character in the typical plants of the crop. If it has, then we may feel considerable confidence that these rogues have been introduced by accidental mixture. The only alternative, indeed, is cross-fertilisation with some distinct variety possessing the dominant, or crossing within the limits of the typical plants themselves occurring in such a way that complementary factors have been brought together. This last is a comparatively infrequent phenomenon, and need not be considered till more probable hypotheses have been disposed of. If the rogues are first crosses the fact can be immediately proved by sowing their seeds, for segregation will then be evident. For example, a truly round seed is occasionally, though very rarely, found on varieties of pea which have wrinkled seeds. I have three times seen such seeds on my own plants. A few more were kindly given me by Mr. Arthur Sutton, and I have also received a few from M. Philippe de Vilmorin—to both of whom I am indebted for most helpful assistance and advice. Of these abnormal or unexpected seeds some died without germinating, but all which did germinate in due course produced the normal mixture of round and wrinkled, proving that a cross had occurred. Cross-fertilisation in culinary peas is excessively rare, but it is certainly sometimes effected, doubtless by the leaf-cutter bee (*Megachile*) or a humble-bee visiting flowers in which for some reason the pollen

has been inoperative. But in peas crossing is assuredly not the source of the ordinary rogues. These plants have a very peculiar conformation, being tall and straggling, with long internodes, small leaves, and small flowers, which together give them a curious wild look. When one compares them with the typical cultivated plants which have a more luxuriant habit, it seems difficult to suppose that the rogue can really be recessive in such a type. True, we cannot say definitely *a priori* that any one character is dominant to another, but old preconceptions are so strong that without actual evidence we always incline to think of the wilder and more primitive characteristics as dominants. Nevertheless, from such observations as I have been able to make I cannot find any valid reason for doubting that the rogues are really recessives to the type. One feature in particular is quite inconsistent with the belief that these rogues are in any proper sense degenerative returns to a wild type, for in several examples the rogues have *pointed* pods like the cultivated sorts from which they have presumably been derived. All the more primitive kinds have the dominant stump-ended pod. If the rogues had the stump pods they would fall in the class of dominants, but they have no single quality which can be declared to be certainly dominant to the type, and I see no reason why they may not be actually recessives to it after all. Whether this is the true account or not we shall know for certain next year. Mr. Sutton has given me a quantity of material which we are now investigating at the John Innes Horticultural Institution, and by sowing the seed of a great number of individual plants separately I anticipate that we shall prove the rogue-throwers to be a class apart. . The pure types then separately saved should, according to expectation, remain rogue-free, unless further sporting or fresh contamination occurs. If it prove that the long and attenuated rogues are really recessive to the shorter and more robust type, the case will be one of much physiological significance, but I believe a parallel already exists in the case of wheats, for among certain crosses bred by Professor Biffen, some curious spelt like plants occurred among the derivatives from such robust wheats as Rivet and Red Fife.

There is another large and important class of cases to which similar considerations apply. I refer to the bolting or running to seed of crops grown as biennials, especially root crops. It has hitherto been universally supposed that the loss due to this cause, amounting in Sugar Beet as it frequently does to five, or even more per cent., is not preventable. This may prove to be the truth, but I think it is not impossible that the bolters can be wholly, or almost wholly, eliminated by the application of proper breeding methods. In this particular example I know that season and conditions of cultivation count for a good deal in promoting or checking the tendency to run to seed, nevertheless one can scarcely witness the sharp distinction between the annual and biennial forms without suspecting that genetic composition is largely responsible. If it proves to be so, we shall have another remarkable illustration of the direct applicability of knowledge gained from a purely academic source. 'Let not him that putteth his armour on boast him as he that putteth it off,' and I am quite alive to the many obstacles which may lie between the conception of an idea and its realisation. One thing, however, is certain, that we have now the power to formulate rightly the question which the breeder is to put to Nature; and this power and the whole apparatus by which he can obtain an answer to his question—in whatever sense that answer may be given—has been derived from experiments designed with the immediate object of investigating that scholastic and seemingly barren problem, 'What is a species?' If Mendel's eight years' work had been done in an agricultural school supported by public money, I can imagine much shaking of heads on the County Council governing that institution, and yet it is no longer in dispute that he provided the one bit of solid discovery upon which all breeding practice will henceforth be based.

Everywhere the same need for accurate knowledge is apparent. I suppose horse breeding is an art which has by the application of common-sense and great experience been carried to about as high a point of perfection as any. Yet even here I have seen a mistake made which is obvious to anyone accustomed to analytical breeding. Among a number of stallions provided at great expense to improve the breed of horses in a certain district was one which was shown me as something of a curiosity. This particular animal had been bred by

one of the provided stallions out of an indifferent country mare. It had been kept as an unusually good looking colt, and was now travelling the country as a breeding stallion, under the highest auspices. I thought to myself that if such a practice is sanctioned by breeding acumen and common-sense, Science is not after all so very ambitious if she aspires to do rather better. The breeder has continually to remind himself that it is not what the animal or plant *looks* that matters, but what it *is*. Analysis has taught us to realise, first, that each animal and plant is a double structure, and next that the appearance may show only half its composition.

With respect to the inheritance of many physiological qualities of divers kinds we have made at least a beginning of knowledge, but there is one class of phenomena as yet almost untouched. This is the miscellaneous group of attributes which are usually measured in terms of size, fertility, yield, and the like. This group of characters has more than common significance to the practical man. Analysis of them can nevertheless only become possible when pure science has progressed far beyond the point yet reached.

I know few lines of pure research more attractive and at the same time more likely to lead to economic results than an investigation of the nature of variation in size of the whole organism or of its parts. By what factors is it caused? By what steps does it proceed? By what limitations is it beset? In illustration of the application of these questions I may refer to a variety of topics that have been lately brought to my notice. In the case of merino sheep I have been asked by an Australian breeder whether it is possible to combine the optimum length of wool with the optimum fineness and the right degree of crimping. I have to reply that absolutely nothing is yet known for certain as to the physiological factors determining the length or the fineness of wool. The crimping of the fibres is an expression of the fact that each particular hair is curved, and if free and untwisted would form a corkscrew spiral, but as to the genetics of curly hair even in man very little is yet known. But leaving the question of curl on one side, we have in regard to the length and fineness of wool a problem which genetic experiment ought to be able to solve. Note that in it, as in almost all problems of the 'yield' of any product of farm or garden, two distinct elements are concerned--the one is *size* and the other is *number*. The length of the hair is determined by the rate of excretion and length of the period of activity of the hair follicles, but the fineness is determined by the number of follicles in unit area. Now analogy is never a safe guide, but I think if we had before us the results of really critical experiments on the genetics of size and number of multiple organs in any animal or even any plant, we might not wholly be at a loss in dealing with this important problem.

A somewhat similar question comes from South Africa. Is it possible to combine the qualities of a strain of ostriches which has extra long plumes with those of another strain which has its plumes extra lustrous? I have not been able fully to satisfy myself upon what the lustre depends, but I incline to think it is an expression of fineness of fibre, which again is probably a consequence of the smallness and increased number of the excreting cells, somewhat as the fineness of wool is a consequence of the increased number and smallness of the excreting follicles.

Again the question arises in regard to flax, how should a strain be bred which shall combine the maximum length with maximum fineness of fibre? The element of number comes in here, not merely with regard to the number of fibres in a stem but also in two other considerations, first, that the plant should not tiller at the base, and, secondly, that the decussation of the flowering branches should be postponed to the highest possible level.

Now in this problem of the flax, and not impossibly in the others I have named, we have questions which can in all likelihood be solved in a form which will be of general, if not of universal, application to a host of other cognate questions. By good luck the required type of flax may be struck at once, in which case it may be fixed by ordinary Mendelian analysis, but if the problem is investigated by accurate methods on a large scale, the results may show the way into some of those general problems of size and number which make a great part of the fundamental mystery of growth.

I see no reason why these things should remain inscrutable. There is indeed

a little light already. We are well acquainted with a few examples in which the genetic behaviour of these properties is fairly definite. We have examples in which, when two varieties differing in number of divisions are crossed, the lower number dominates—or, in other words, that the increased number is a consequence of the removal of a factor which prevents or inhibits particular divisions, so that they do not take place. It is likely that in so far as the increased productivity of a domesticated form as compared with its wild original depends on more frequent division, the increase is due to loss of inhibiting factors. How far may this reasoning be extended? Again we know that in several plants—peas, sweet peas, *Antirrhinum*, and certain wheats—a tall variety differs in that respect from a dwarf in possessing one more factor. It would be an extraordinarily valuable addition to knowledge if we could ascertain exactly how this factor operates, how much of its action is due to linear repetition, and how much to actual extension of individual parts. The analysis of the plants of intermediate size has never been properly attempted, but would be full of interest and have innumerable bearings on other cases in animals and plants, some of much economic importance.

That in all such examples the objective phenomena we see are primarily the consequence of the inter-action of genetic factors is almost certain. The lay mind is at first disposed, as always, to attribute such distinctions to anything rather than to a specific cause which is invisible. An appeal to differences in conditions—which a moment's reflection shows to be either imaginary or altogether independent—or to those vague influences invoked under the name of Selection, silently postponing any laborious analysis of the nature of the material selected, repels curiosity for a time, and is lifted as a veil before the actual phenomena; and so even critical intelligences may for an indefinite time be satisfied that there is no specific problem to be investigated, in the same facile way that, till a few years ago, we were all content with the belief that malarial fevers could be referred to any damp exhalations in the atmosphere, or that in suppuration the body was discharging its natural humours. In the economics of breeding, a thousand such phenomena are similarly waiting for analysis and reference to their specific causes. What, for instance, is self-sterility? The phenomenon is very widely spread among plants, and is far commoner than most people suppose who have not specially looked for it. Why is it that the pollen of an individual in these plants fails to fertilise the ova of the same individual? Asexual multiplication seems in no way to affect the case. The American experimentors are doubtless right in attributing the failure of large plantations of a single variety of apples or of pears in a high degree to this cause. Sometimes, as Mr. W. O. Backhouse has found in his work on plums at the John Innes Horticultural Institution, the behaviour of the varieties is most definite and specific. He carefully self-fertilised a number of varieties, excluding casual pollination, and found that while some sorts, for example, Victoria, Czar, and Early Transparent, set practically every fruit self-pollinated, others including several (perhaps all) Greengages, Early Orleans, and Sultan do not set a single fruit without pollination from some other variety. Dr. Erwin Baur has found indications that self-sterility in *Antirrhinum* may be a Mendelian recessive, but whether this important suggestion be confirmed or not, the subject is worth the most minute study in all its bearings. The treatment of this problem well illustrates the proper scope of an applied science. The economic value of an exact determination of the empirical facts is obvious, but it should be the ambition of anyone engaging in such a research to penetrate further. If we can grasp the *rationale* of self-sterility we open a new chapter in the study of life. It may contain the solution of the question, What is an individual?—no mere metaphysical conundrum, but a physiological problem of fundamental significance.

What, again, is the meaning of that wonderful increase in size or in 'yield' which so often follows on a first cross? We are no longer content, as Victorian teleology was, to call it a 'beneficial' effect and pass on. The fact has long been known and made use of in breeding stock for the meat market, and of late years the practice has also been introduced in raising table poultry. Mr. G. N. Collins,[1] of the U.S. Department of Agriculture, has recently proposed with much reason that it might be applied in the case of maize. The cross is easy to

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[1] Bureau of Plant Industry, Bulletin No. 191, 1910.

make on a commercial scale, and the gain in yield is striking, the increase ranging as high as 95 per cent. These figures sound extravagant, but from what I have frequently seen in peas and sweet peas, I am prepared for even greater increase. But what *is* this increase? How much of it is due to change in number of parts, how much to transference of differentiation or homoeosis, as I have called it—leaf-buds becoming flower-buds, for instance—and how much to actual increase in *size* of parts? To answer these questions would be to make an addition to human knowledge of incalculably great significance.

Then we have the further question, How and why does the increase disappear in subsequent generations? The very uniformity of the cross breds between pure strains must be taken as an indication that the phenomenon is orderly. Its subsidence is probably orderly also. Shull has advocated the most natural view that heterozygosis is the exciting cause, and that with the gradual return to the homozygous state the effects pass off. I quite think this may be a part of the explanation, but I feel difficulties, which need not here be detailed, in accepting this as a complete account. Some of the effect we may probably also attribute to the combination of complementary factors; but whether heterozygosis, or complementary action, is at work, our experience of cross-breeding in general makes it practically certain that genetic factors of special classes only can have these properties, and no pains should be spared in identifying them. It is not impossible that such identification would throw light on the nature of cell division and of that meristic process by which the repeated organs of living things are constituted, and I have much confidence that in the course of the analysis discoveries will be made bearing directly both on the general theory of heredity and on the practical industry of breeding.

In the application of science to the arts of agriculture, chemistry, the foundation of sciences, very properly and inevitably came first, while breeding remained under the unchallenged control of simple common-sense alone. The science of genetics is so young that when we speak of what it also can do we must still for the most part ask for a long credit; but I think that if there is full co-operation between the practical breeder and the scientific experimenter, we shall be able to redeem our bonds at no remotely distant date. In the mysterious properties of the living bodies of plants and animals there is an engine capable of wonders scarcely yet suspected, waiting only for the constructive government of the human mind. Even in the seemingly rigorous tests and trials which have been applied to living material apparently homogeneous, it is not doubtful that error has often come in by reason of the individual genetic heterogeneity of the plants and animals chosen. A batch of fruit trees may be all of the same variety, but the stocks on which the variety was grafted have hitherto been almost always seminally distinct individuals, each with its own powers of luxuriance or restriction, their own root-systems, and properties so diverse that only in experiments on a colossal scale can this diversity be supposed to be levelled down. Even in a closely bred strain of cattle, though all may agree in their 'points,' there may still be great genetic diversity in powers of assimilation and rapidity of attaining maturity, by which irregularities by no means negligible are introduced. The range of powers which organic variation and genetic composition can confer is so vast as to override great dissimilarities in the conditions of cultivation. This truth is familiar to every raiser and grower, who knows it in the form that the first necessity is for him to get the right breed and the right variety for his work. If he has a wheat of poor yield, no amount of attention to cultivation or manuring will give him a good crop. An animal that is a bad doer will remain so in the finest pasture. All praise and gratitude to the student of the conditions of life, for he can do, and has done, much for agriculture, but the breeder can do even more.

When more than fifteen years ago the proposal to found a school of agriculture in Cambridge was being debated, much was said of the importance of the chemistry of soils, of researches into the physiological value of food-stuffs, and of other matters then already prominent on the scientific horizon. I remember then interpolating with an appeal for some study of the physiology of breeding, which I urged should find a place in the curriculum, and I pointed out that the improvement in the strains of plants and animals had done at least as much—more, I really meant—to advance agriculture than had been accomplished by other means. My advice found little favour, and I was taken to

task afterwards by a prominent advocate of the new school for raising a side issue. Breeding was a purely empirical affair. Common-sense and selection comprised the whole business, and physiology flew at higher game. I am, nevertheless, happy now to reflect that of the work which is making the Cambridge School of Agriculture a force for progress in the agricultural world the remarkable researches and results of my late colleague, Professor Biffen, based as they have been on modern discoveries in the pure sciences of breeding, occupy a high and greatly honoured place.

In conclusion I would sound once more the note with which I began. If we are to progress fast there must be no separation made between pure and applied science. The practical man with his wide knowledge of specific natural facts, and the scientific student ever seeking to find the hard general truths which the diversity of Nature hides—truths out of which any lasting structure of progress must be built—have everything to gain from free interchange of experience and ideas. To ensure this community of purpose those who are engaged in scientific work should continually strive to make their aims and methods known at large, neither exaggerating their confidence nor concealing their misgivings,

> 'Till the world is wrought
> To sympathy with hopes and fears it heeded not.'

The following Papers were then read :—

1. *Cider-Sickness.* *By* B. T. P. Barker, *M.A.*, *and* V. Florian Hillier.

Cider-sickness is a disorder of common occurrence which generally makes its appearance in ciders in the early part of the summer. The first symptoms of the attack are a characteristic frothing of the liquor and a sudden and violent evolution of gas. The pleasant fruity character of the cider disappears and a disagreeable peculiar odour and taste are produced. After a short time the cider generally becomes turbid and suffers some loss of colour. In some cases the turbidity increases until the liquor attains a thick milky condition, while in other instances the cider itself remains comparatively clear but a copious deposit is precipitated. The turbidity is due partly to bacteria mixed with a few yeast cells and torulæ, but mainly to the formation of a substance which is thrown out of solution in the form of aggregations of minute droplets or granules which when examined microscopically may easily be mistaken for groups of small cocci. The nature of the substance has not yet been fully investigated, but it is possibly a derivative of the colouring matters of the cider. It is partially dissolved on heating the cider and is, when freshly precipitated, soluble in alcohol. Occasionally the deposition of this substance is absent in cases of sickness.

The gas evolved during sickness consists mainly of carbon dioxide, and a small percentage of hydrogen is also produced. The specific gravity of the cider falls rapidly during sickness, owing to the destruction of the sugar, and the percentage of alcohol is increased. The acidity also rises slightly. Under conditions favourable to the disorder the fermentation may continue until the sugar almost entirely disappears; but occasionally, for what reason it is not at present clear, it may suddenly cease, leaving a considerable quantity of sugar untouched. Cider after sickness is prone to rapid acetification. Ciders most liable to sickness are those containing relatively large amounts of unfermented sugar, and are generally those of the best quality. Consequently the loss to the makers is very serious, and probably amounts to several thousands of pounds per annum in the West of England alone. Other conditions favouring sickness are a naturally slow rate of fermentation of the cider, a low degree of acidity, and a high temperature. Contrary to the generally accepted idea the presence of a large amount of tannin in the cider does not appear to offer much check to the disorder.

Perry is also liable to the same trouble.

An examination of the flora of sick ciders has led to the isolation of a bacterium which can produce all the symptoms of sickness in sterilised ciders and perry infected with pure cultures of it. The characters of the organism have been studied in detail. It is motile and facultatively anærobic. Its optimum temperature of growth is about 30° C. No growth has been observed above 40° C.,

and at temperatures below 12° to 15° C., growth is extremely slow. It can ferment dextrose and lævulose, producing alcohol and an evolution of gas which consists of about 95 per cent. carbon dioxide and 5 per cent. hydrogen. A characteristic acid odour resembling that of decaying lemons is also formed in dextrose solutions. The acidity of the solution is somewhat increased, but the presence of any of the commoner organic acids has not been recognised. Neither saccharose, maltose, nor lactose appear to be attacked by it. It grows best in neutral or very slightly acid media. Solutions containing more than 0·5 per cent. malic acid are unfavourable to its development. It can ferment beer wort, but the characteristic aroma and flavour of sickness are not produced. Growth is slight on all the solid media tested. Gelatine is not liquefied by it.

The most promising measures for combating the disorder are sterilisation of all vessels and appliances which have been contaminated with sick cider, storage at a low temperature, and suitable blending of ciders to raise the acidity above 0·5 per cent. malic acid and to give a moderately rapid normal rate of fermentation. It has also been observed that ciders liable to the disorder will escape if bottled very early in the season, whereas if bottled at the usual period they quickly turn sick.

2. *A Method of determining the Baking Strength of Single Ears of Wheat.*

By H. W. Harvey, *B.A., and* T. B. Wood, *M.A.*

The advance of plant breeding on Mendelian lines has created a demand for methods of discrimination between individual plants, and this is especially the case with wheats. The authors have met with some success in the use of the following method for picking out 'strong' wheats, and take this opportunity of commending it to others who may be working on similar lines.

It has been shown that the physical characters of the gluten of any given wheat depend on the acidity and the salt content of the cell sap.[1] The authors have since found that while certain concentrations of acid and salt cause the gluten to become coherent, a certain proportion of the protein is at the same time dissolved. The solution of this protein possesses the ordinary characters of a colloid solution. It is difficult to filter, rather viscous, and opalescent. In experimenting with water-extracts of various wheats, the authors noticed great differences in these characters, especially in opalescence. The difference in respect of the latter property is greatly increased on addition of iodine, which combines with the dissolved protein and forms a turbidity which has little tendency to settle. Working on these lines, they have devised a method which makes it possible to differentiate between flours with samples of about one gram. The method is as follows: 1 gram of the sample is shaken with 20 c.c. of cold water for one hour and then filtered. To 10 c.c. of the more or less opalescent solution, 1 c.c. of 0·1 per cent. solution of iodine in potassium iodide is added. After standing for one hour, the turbid solution is poured into a narrow tube with a plane-glass bottom. A very small electric lamp is placed vertically under the tube. A plunger made of narrow tube with a plane-glass bottom is screwed downwards by means of a rack and pinion into a turbid liquid until the filament of the lamp just becomes visible. The depth of the liquid is then read off on a scale. Working on these lines, the filament can be seen through the following depths:—

	c.m.
Fife	3–4
Karachi	6–8
Square Heads' Master	10–12
Rivett	15–18

In all these cases the turbidity goes in the same order as the shape of the loaf.

The method lends itself well to the testing of single ears. The grain from an ear is rubbed out and ground in a small mill. One gram of the metal is weighed out and treated as described above for flour.

The authors have already succeeded in this way in picking out 'strong' and

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[1] T. B. Wood, *J. of Agr. Sc.*, vol. 2, pp. 139 and 267.

'weak' plants from second generation cultures grown by Professor Biffen from the following crosses: Polish×Rivett, Fife×Rivett, Fife×Rough Chaff.

The authors are at present engaged in standardising the method more completely. They take this early opportunity of publishing a preliminary note, since methods of picking out 'strong' and 'weak' individual plants are so urgently needed.

3. *The Effects of Ventilation on the Temperature and Carbon Dioxide of the Air of Byres.* *By* JAMES HENDRICK, *B.Sc.*

It is firmly believed among dairy farmers in, at any rate, many parts of the country that it is important to keep the byres warm if dairy cows are to give a full flow of milk. It is not economical to maintain the temperature in winter by artificial heating, and in order to keep it up by the heat of the animals themselves it is usual for farmers to restrict the ventilation, especially in byres where the cubic capacity per animal is great. The temperature is thus maintained by keeping in the warm polluted atmosphere, and the colder and more boisterous the weather the more the circulation of air is restricted.

The author was associated with the late Mr. John Spier, Newton Farm, Glasgow, in carrying out experiments on the 'Influence of Temperature on Milk Yield.' In experiments carried on during the winters 1908-09 and 1909-10 cows were divided into two lots, and one lot was kept warm by restricting ventilation in the usual way, while the similar byre in which the other lot was kept was well ventilated, no matter what the temperature fell to. In each winter the experiment was carried on at five different centres. In 1908-09, 100 cows were under experiment, and in 1909-10, 104 cows.

Temperature records for all byres were continuously kept during the whole course of the experiments. In order to measure the pollution of the air the carbon dioxide gas was determined periodically. The average temperature for the whole period, November to March, was in 1908-09, in the byres with restricted ventilation, 59·4° F., and in the freely ventilated byres 49·8° F.; and in 1909-10 in the byres with restricted ventilation 57·3° F., and in the freely ventilated byres 49·0° F.

The carbon dioxide found is shown in the following table:—

Parts of CO_2 per 10,000.

	1908-09		1909-10	
	Variation	Average	Variation	Average
Restricted ventilation .	9·0 to 88·9	30·8	9·0 to 105·5	29·6
Free ventilation .	6·5 to 24·8	12·1	3·5 to 40·0	15·3

The carbon dioxide in the byres with restricted ventilation is on the average nearly twice as high as that in the freely ventilated byres. In both cases great variations were found between different samples. In neither case was the air on the average very pure, but in many cases the impurity, as indicated by the carbon dioxide, was very serious in the byres with restricted ventilation.

The byres used in these experiments were distinctly above the average of the dairy byres of the country in average space per cow, in ventilation, and in general appointments. It may, therefore, safely be concluded that the impurity of the air shown in the byres with restricted ventilation is not greater than that which prevails in the ordinary dairy byres of the country. During these experiments the milk yield was as great in the freely ventilated as in the badly ventilated byres, and the health of the cows was better in the freely ventilated byres than in the others. Attempts were made to measure the bacteriological pollution of the atmosphere, but on account of the difficulties which arose these had to be abandoned.

These experiments indicate that it is more important to have fresh air in byres than a large cubic space per cow.

4. *Self-sterility and Self-fertility in Plums.* *By* W. O. BACKHOUSE.

The object of these experiments when first undertaken was not to see which varieties of plum were self-sterile and which self-fertile, but to start a systematic inquiry into the gametic composition of our commoner plums, with a view to putting the raising of new plums on a scientific basis.

Accordingly, in 1910 suitable branchlets of the following plums were enclosed in paper bags, before the flowers had opened, to exclude insects and foreign pollen. Subsequently, when at the height of the flowering period, the bags were taken off and the flowers carefully hand pollinated; being then covered up again immediately.

Results.

Victoria	7 bags, covering on an average twenty flowers each. Nearly every flower set, and the fruit had to be heavily thinned.
River's Early Prolific	8 bags; set, nine fruits.
Greengage . . .	5 bags; set, four fruits, all in one bag, which was broken.

Nine emasculated flowers of greengages, crossed River's Early Prolific, gave nine seeds. This year, this was repeated and extended, giving results as follows:—

Trees in Open.

River's Early Prolific .	28 bags, 2 fruits.	
Victoria	30 bags	All set to such an extent that the fruit had to be heavily thinned to allow it to develop properly.
Prince Englebert . .	3 "	
Czar	12 "	
Pershore	18 "	
Yellow Magnum Bonum	15 "	
Damson (var.) . .	7 "	
A 'sloe' Prunus spinosa	11 bags	All set absolutely nothing.
Histon Gage . . .	10 "	
Early Orleans . .	28 "	
Late Orleans . .	15 "	
Late Orange . . .	19 "	
Sultan	16 "	
Korke's Blue . . .	3 "	

Pot trees flowered in a fruit-house of the John Innes Horticultural Institution under conditions where insects were almost entirely excluded, and which were carefully hand pollinated with their own pollen, flower by flower.

Denniston's Superb . . .	Set nearly every flower.
Early Transparent . . .	
Reine Claude Violette . . .	
River's Early Prolific . . .	10 fruits out of 110 flowers circa.
2 Trees Coe's Golden Drop . .	Set nothing, with the exception of one Reine Claude d'Althan fruit and two on Old Greengage, which were all in positions which make an accidental touch very probable.
Washington	
Late Transparent. . . .	
Blue Imperatrice	
Early Greengage	
Old Greengage	
2 Trees Reine Claude d'Althan. .	

It is interesting to note that in the above cases where a plum is self-sterile if the flower is not pollinated at all, it falls in three or four days. If self-pollinated, the carpel may swell to the size of a culinary pea before dropping and on sectioning there is seen to be a great development of nucellus tissue.

5. *The Mucilage of Linseed.* *By* H. A. D. Neville, *B.Sc.*

The author is engaged in investigating the chemical composition and feeding value of the mucilage of linseed. Up to the present he has succeeded in establishing the following points:—

1. The amount of mucilage contained in linseed is about seven per cent.

2. As prepared by swelling up the seeds in very dilute sulphuric acid and precipitation from the colloid solution thus obtained by means of much alcohol, mucilage is a slightly acid substance, with a percentage composition approximating to that of a carbohydrate, and containing a small amount of ash.

3. Purification by repeated solution in water and precipitation by alcohol lowers the ash-content somewhat, but does not remove the acid property.

4. On hydrolysis with dilute sulphuric acid, the following substances are formed: Dextrose, galactose, arabinose, xylose,[1] and small amounts of a cellulose-like substance, and of an acid which forms a soluble barium salt.

5. On boiling with hydrochloric acid, furfurol is evolved in quantity corresponding to the presence in the mucilage of about 17 per cent. of pentosans.

6. Malt extract, saliva, and pancreatic juice are found to be without action on the mucilage.

7. It has not been possible to isolate the mucilage from the dung of rats, guinea pigs, or cows eating large rations of linseed.

8. The mucilage is readily decomposed by the bacteria of the cæcum. Solutions of mucilage inoculated with a drop of cæcum contents rapidly ferment. The mucilage disappears, the solution becomes acid, and carbon dioxide and a mixture of inflammable gases are evolved.

The investigation is still proceeding.

6. *British Weights.* *By* John Porter, *B.Sc.*

The present systems of weights and measures are very complicated. British subjects do not take kindly to the metric (centimetre, gramme, second) system because the physical sciences, trade, and commerce have been built up on the British (foot, pound, second) system.

Fundamental Units.—A new system in this country must obviously recognise the existing units of weight, volume, and measurement; then a decimal system built up on these units would not inflict any great hardships with weights which were multiples of one pound; *e.g.*, 10 lb. can easily be weighed out with ordinary weights, and so can 50, 100, or 1,000 lb. Hence existing weights could be used for a number of years. A decimal connection between weight and volume is most desirable. One gallon (277·463 cubic inches) of distilled water at 62° F. and 30 inches barometric pressure weighs 10 lb. The tenth part of a gallon (1 lb.) could easily be taken as the unit of volume. The connection between volume and lineal measure could probably be overcome by using a liquid of a different density from water, but water must be the standard, as its use as a standard in the sciences is so deeply rooted. It is therefore only possible to connect two of the three units (weight, volume, and length) in a decimal manner, and the most important connection is that of weight and volume. The decimal system is already in use in surveying (10 square chains = 1 acre).

Suggested System of Weights (Unit, 1 lb. Avoirdupois).

1. *Multiples.*

Centels	Tuns	Centals	Dekels	Pounds (Avoirdupois)
Ctls.	(New tons) Tuns	(New cwts.) Ctls.	(New stone) Dkls.	Lb.
—	—	—	—	1
—	—	—	1	10
—	—	1	10	100
—	1	10	100	1,000
1	10	100	1,000	10,000

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[1] Hilger, *Ber.*, 1903, **36**, 3197.

Higher multiples may be obtained by changing the vowel in cental, viz., cental, 100 lb.; centel, 100^2 lb.; centil, 100^3 lb. (million); centol, 100^4 lb.; centul, 100^5 lb.; centyl, 100^6 lb. (billion). Numbers could be very simply reduced to centals, &c.; *e.g*, 2,347 lb. equals 2 tuns, 3 centals, 4 dekels, 7 lb.

Useful connections with existing Weights.—The multiples would be mostly used in agriculture, trade, commerce, science (hydrostatics), &c., and need cause little trouble, seeing that the unit employed is still the same. The score (20 lb.) is a common weight in agriculture, and the quarter (480 lb.), boll (240 lb.), pack (240 lb.), and windle (220 lb.), are usually expressed as so many 'scores.' Five scores equal 1 cental, and 1 score equals 2 dekels. The cental is used already in this country (Liverpool and Manchester) and in America. A cental would be approximately the weight of a good 'hogg' or 'teg,' and ten times this (one tun) about the weight of a store bullock. The 'dekel' (10 lb.) is the weight of a gallon of water, which would be a useful 'derived' weight in physical science.

2. *Sub-Multiples.*

Tels	Uns	Tals	Kals	Pound (Avoirdupois)	Grains (Avoirdupois)
10,000	1,000	100	10	1	7,000

The above-named are derived from the corresponding words used as multiples, and consist of the latter part of each word employed. Further subdivisions, if necessary, with exceedingly rare chemicals could be obtained in the same way as the higher multiples; *e.g.*, tal, 1/100 lb.; tel, $1/100^2$ lb.; til, $1/100^3$ lb., &c.

The adoption of this system would affect the apothecary, jeweller, &c., but the difficulties would be more apparent than real, as a small table of equivalents would give the necessary information; *e.g.*, the grain is of the same value troy, apothecaries', and avoirdupois, and is in use in most countries. It will be seen at a glance that 7 grains are equal to 10 tels; 1 grain is therefore very nearly equal to 1½ tels. The drachm avoirdupois is $\frac{1}{256}$ lb., and is approximately equal to 3·9 uns. The ounce avoirdupois (437½ grains) is the one used in the British Pharmacopœia, and is equal to 6·25 tals.

With the grain common to troy, apothecaries', and avoirdupois weights it would appear possible by a little united effort to establish a uniform decimal system of weights of the greatest possible advantage.

FRIDAY, SEPTEMBER 1.

The following Papers were read :—

1. *Discussion on Bacterial Diseases of Plants.*

(i) *Bacterial Diseases of Plants. By* Professor M. C. POTTER, *M.A.*

The existence among plants of diseases which are caused by the invasion of parasitic bacteria is a fact which will hardly be disputed in the present day. A preconception once widely held, that the special features of plant structure, the nature of the cell-sap, and the impervious character of the cell-wall rendered the plant organism impregnable to bacterial attack, has been shown to be entirely erroneous; and it has been abundantly proved, under rigid conditions of experiment, that certain bacterial diseases of plants could be reproduced in healthy tissues with absolute certainty, and would develop the characteristic pathogenic symptoms as surely as any of the most virulent forms of animal parasite.

The plant possesses many vulnerable points of attack, and infection has been shown to take place through the water-pores, the stomata, the floral nectaries, and through wounds, the vessels of the xylem affording a suitable channel for the

dispersion of the invading bacilli. Further, certain bacteria have the power of secreting a toxin and cytolitic enzyme which effect the destruction of the protoplasm and rapid degeneration of cellulose, and the actual penetration of the bacterium through the cell-wall has been observed. A complete homology has been established between the parasitism of bacteria and that of various parasitic fungi. In the same manner as fungi, bacteria also exist as saprophytes, which have the faculty, under certain conditions, of developing into virulent parasites, and their aptitude as parasites may be increased or suppressed upon subjection to variations of nutrition.

There are various well-marked types of bacterial disease which differ considerably in their pathological character and in the extent of the injury which is produced. Some are characterised by rapid proliferation of the cells, forming galls or tumour-like structures; in some the bacilli are confined to the vascular tissue, in others their action extends through the parenchyma; and in many cases, such as the 'Soft Rots,' spreads throughout the entire cell-complex until the whole plant becomes reduced to a putrefying mass. The organisms which are pathogenic to cultivated plants are more particularly considered, and the different external conditions which influence the susceptibility to disease. The nature of the soil, manurial treatment, and other factors materially affect the constitution of both host and parasite, and determine to a large extent the predisposition to infection by bacteria.

(ii) *Bacterial Gum Diseases.* *By* F. T. Brooks, *M.A.*

1. *Gum Disease of the Sugar Cane.* In 1893 Cobb described a 'gum disease' of the sugar-cane in Australia, one of the chief features of the disease being the presence of a gummy substance in the vascular bundles of the stem. Cobb attributed the disease to the action of a bacterium which he named *Bacillus vascularum.* He performed certain inoculation experiments, but as they were not carried out under critical conditions the results were generally considered to be inconclusive.

In 1904 Erwin F. Smith,[1] working in America, proved conclusively that the disease was caused by a specific bacterium which he named *Pseudomonas vascularum.* This organism was plated out from diseased canes and grown in pure culture. Inoculations with the bacterium cultivated in this manner gave rise to the characteristic signs of the disease. The same bacterium was plated out from the inoculated canes.

2. *A Bacterial Disease of Cherry Trees.*—Aderhold and Ruhland[2] have recently proved that a disease of cherry trees in Germany is caused by a bacterium which they name *Bacillus spongiosus.* Affected trees exhibit symptoms similar to those of pear trees attacked by 'pear blight,' which is also a bacterial disease. Young trees are attacked, shoots and entire trees being sometimes killed. Profuse gumming occurs in the affected parts. Aderhold and Ruhland isolated *Bacillus spongiosus* from the masses of gum and grew this organism in pure culture. Inoculation experiments clearly showed that this bacterium was the cause of the disease. This organism is not the only cause of gumming, for certain injurious fungi are known to induce similar exudations from cherry trees.

3. *Mosaic Disease of the Tobacco Plant.*—This disease is present in almost every region where tobacco is cultivated. Mayer[3] and Iwanowski[4] formerly attributed it to bacterial agency, but more recent work by Hunger[5] and others points rather to the conclusion that the disease is not due to any specific organism but to some physiological disturbance within the plant.

(iii) *Bacterial Diseases of the Potato-plant in Ireland.*
By Dr. G. W. Pethybridge.

The presence of bacterial disease among potatoes in Ireland has been suspected for some considerable time, but no definite proof of the existence of such disease has hitherto been forthcoming. As a result of a couple of seasons' study carried on in the West of Ireland at a temporary research station established by

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[1] *Cent. f. Bakteriologie*, 1904.

[2] *Ber. d. Deut. Bot. Ges.*, 1906.

[3] *Landwirt. Versuchstat.*, 1886.

[4] *Zeit. f. Pflanzenkrank.*, 1903.

[5] *Ibid.*, 1905.

the Department of Agriculture and Technical Instruction, it has been found possible to disentangle from a congeries of diseases, formerly somewhat indefinitely described under the name of 'yellow blight,' a definite bacterial disease of the potato to which the name of 'Black Stalk Rot' has been given. The disease resembles the 'Black Leg,' 'Schwarzbeinigkeit,' &c., of other authors, and is caused by an organism which is not absolutely identical with any of those hitherto described, and which has been named *Bacillus melanogenes*. The main symptoms of the disease are a wilting and yellowing of the foliage, a degeneration of the vascular bundles of the stalks, and decay of their subterranean portions and of the tubers. The disease is apparently spread chiefly by the planting of affected tubers, which are not easily recognised as such. Its importance consists not only in the fact that plants are killed in the field by the organism, but also in that the latter produces a most serious rot in stored potatoes, even healthy unwounded tubers being capable of infection through their lenticels when in contact with diseased material. Preventive measures should aim at the destruction of attacked plants in the field, the total exclusion of affected tubers from pits and clamps, so far as this is possible, and the construction of the pit and clamp in such a way that the conditions favourable to the development of the organism (moisture and warmth) are not present.

(iv) *Potato Disease.* *By* A. S. Horne, *B.Sc., F.G.S.*

This paper dealt with the following topics:—

The power of the cell of the potato tuber to respond to altered physiological conditions: (*a*) under certain circumstances storage cells assimilate; (*b*) storage cells may be modified in connection with the formation of intumescences; (*c*) they may become meristematic; and (*d*) the effect of over stimulation.

The potato plant relative to its environment: (*a*) artificial stimulation of germinating tubers; (*b*) the experiments of Raoul Combes; (*c*) various experiments.

The probability that a plant will thrive in a given spot depends upon certain combinations of factors. These may be conveniently grouped as follows:—

(1) Factors relating to structure and internal constitution of the plant, and to the organisms intimately associated with it.
(2) Factors relating to the soil and organisms present in the soil.
(3) Factors relating to the climate and season, and to aerially borne organisms.

Disease may occur if the optimum arrangement of factors be disturbed. The experimental production of soft rot (Nassfäule) in the laboratory. The artificial production of 'Leaf Blotch' and probable explanation of this disease. The phenomena attending 'Leaf Curl' and 'Leaf Roll' (Blattrollkrankheit). 'Black-leg' in potato. The importance of arriving at a correct and full knowledge of the life-history of potato pests, with special reference to *Phytophthora infestans* and *Spongospora solani*. Local epidemics of *Spongospora* in 1910. Internal disease of potato. Potato breeding in relation to plant pathology.

(v) *A Bacterial Disease of the Potato Plant.* *By* Miss E. Dale.

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2. *The Influence of Electricity on Micro-organisms.* *By* J. H. Priestley *and* Miss E. M. Lee.

This paper dealt with the investigation of the effect of weak currents of electricity upon micro-organisms, using the rate of production of their metabolic products as an index of their rate of growth.

The organisms selected as the result of many preliminary trials were *B. Bulgaricus*, the 'sour milk' bacillus of Professor Metchnikoff. A very active strain, producing 1·4 per cent. of lactic acid in ten hours, was procured, and pure cultures were used throughout the work.

Milk cultures of the bacillus were set up in Kohlrausch electrolytic cells and

subjected to currents of strengths varying from 0·3 to 80 microampères at 40° C. The effect of this treatment on the activity of the bacteria was detected by measuring the *change* in electrical resistance of the milk culture after a period of some twenty-four hours. In all cases control cultures of sterile milk containing the same number of bacteria were set up under the same conditions of temperature, &c., but having no current passed through them.

The resistance was measured by means of a Kohlrausch apparatus for the determination of the conductivity of liquids. In this method an alternating current traverses the electrolyte, and a telephone is used to detect the point of balance. All measurements were made with the cultures kept at the same temperature in a water bath controlled by a thermostat. The effect on the production of metabolic products as indicated by the change in resistance of the culture treated was considerable, and seems to be directly due to the action of the current on the bacteria. Counts of the bacteria made by the usual methods also indicated more rapid growth in the electrified culture. The maximum effect seems to be produced by a current of about 60 microampères. Currents of greater strength inhibit the activity of the bacteria as measured by the change in conductivity of the liquid.

There was no appreciable difference between the effects produced by direct and alternating currents, so that it seems that no detrimental effect has been produced in the former case by the accumulation of the products of electrolysis in the region of one electrode.

3. *Influence of Electricity on the Respiration of Germinating Seeds.*

By J. H. Priestley *and* R. C. Knight.

In many experiments upon the electrification of plants an acceleration in growth has been reported, accompanied with an earlier attainment of maturity and consequent more rapid harvesting of such electrified crops.

This appears to indicate an acceleration of the normal vital processes of the plant, and it was thought that an increase in the rate of respiration might act as an index to such accelerated vital processes and enable some idea to be obtained as to the electrical condition most favourable to such acceleration. With this in view a long series of experiments have been carried out, the methods and results of which are briefly summarised below.

Experiments were carried out to determine the relative amounts of respiration going on in germinating seeds under normal conditions and under the influence of electricity.

The method was to determine the weight of carbon dioxide evolved in the two cases by absorbing it in baryta solution. A slow stream of air rendered free from carbon dioxide was passed over the seeds, which were enclosed in an otherwise airtight tube or bulb, whichever was best fitted to the required experimental conditions. The stream was then carried through a standard solution of baryta in a Pettenkofer tube, where the carbon dioxide was precipitated. The change in the strength of this solution was then determined by titration with a standard solution of oxalic acid, using phenol-phthalein as indicator, and thus the weight of carbon dioxide present was calculated.

This Pettenkofer tube was replaced hourly by a fresh one, and, as a rule, the seeds, usually peas, were subjected to normal conditions and electrical influence alternately for an hour each, so that the amount of carbon dioxide in the first tube represented the normal respiration, and the amount in the second the respiration resulting from altered conditions.

The following sets of experiments were carried out :—

1. *Effect of a Direct Current.*—Current was supplied from the college mains, the terminals being connected with unpolarisable electrodes penetrating the rubber stoppers of the long respiration tube. Contact was ensured by packing the seeds tightly together. Currents varying from 0·75 to 9·0 milliampères were employed, and the results showed a considerable decrease in respiration on electrification, the difference amounting to ·20 per cent. or 30 per cent. The higher currents produced a slightly larger decrease.

2. *The same Current Source, direction of the Current rapidly reversed.*—A sechometer was introduced into the circuit in these experiments, and the effect

on respiration varied with the current, 50 microampères producing an increase of about 30 per cent., whilst 150 microampères had no effect, and 500 to 600 microampères resulted in a 20 per cent. decrease, these figures being approximations. Considering the variability of different sets of seeds, which was shown by experiment, the results show marked consistency.

3. *Overhead Discharge.*—The positive pole of an electrical machine was connected with a platinum loop above the seeds, which were themselves 'earthed.' Thus discharge passed from 'point' to seeds. The results were irregular at first, and this was traced to the evolution of ozone, which in the confined atmosphere exerts a very depressing effect upon the output of carbon dioxide. A beaker of turpentine was inserted to absorb the ozone, and then increase of respiration resulted on electrification. The amount of increase varied with different sets of seeds, the largest obtained being 110 per cent. with peas.

4. *The Soils and Farming of the South Downs.* *By* A. D. HALL, *F.R.S.*

MONDAY, SEPTEMBER 4.

Discussion on how best the University Agricultural Departments may come in contact with the Farmer.

(i) *A Consideration of the Irish System as modified to suit English Conditions*

By R. HART-SYNNOT.

(ii) *Ways in which the University may help the Farmer.*

By J. R. AINSWORTH-DAVIS.

(1) Conduct of original research relevant to agriculture and dissemination of results obtained. When open-air work is required farmers are always willing to give facilities.

(2) Bureau of information in cases of difficulty, where knowledge of farm institutes and so forth may be inadequate.

(3) Training of experts to take part in higher grades of research, experiment, and education.

(4) Provision of agricultural education for those destined to be concerned with the land on a large scale, other than as in (3).

(5) Taking the lead in correlation of agricultural research, experiment, and education within a given sphere of influence.

(6) Provision of summer schools of agriculture for teachers in secondary and elementary rural schools.

(7) Provision of extension lectures and classes in suitable centres.

(iii) *The Place of the Agricultural Instructor.* *By* J. H. BURTON.

Joint Discussion with Section B on the Part played by Enzymes in the Economy of Plants and Animals.—See p. 365.

TUESDAY, SEPTEMBER 5.

The following Papers were read:—

1. *The Application of Genetics to Horse-breeding.* *By* C. C. HURST, *F.L.S.*

Soon after the discovery of Mendel's work in 1900, my attention was directed to the thoroughbred horse as a promising subject for investigation. The question of coat-colour provided a useful beginning. A few years' investigation of Wetherby's 'General Stud Book' brought to light the fact that chestnut coat-colour is recessive to bay and brown. Consequently chestnut horses always breed true when mated together, notwithstanding their possible bay and brown parents and ancestors. On the other hand, bay and brown horses are of two kinds, either they throw chestnuts or they do not.[1]

Further investigation showed that grey coat-colour is dominant to bay, brown, and chestnut. Consequently every grey horse must have a grey parent and a grey ancestor in every generation in the direct line. In England grey thoroughbreds are few, and grey × grey matings are rare, consequently English grey thoroughbreds are nearly all heterozygous, throwing bays, browns, or chestnuts. Mr. R. Bunsom has found a homozygous grey in Germany, the Arabian stallion, Celle Amurath, which throws nothing but greys.[2]

The genetic relationships between bay and brown, and between grey and roan, are not yet known.

With regard to black, Professor James Wilson has pointed out that in thoroughbreds all the so-called 'blacks' are really dark browns with tan muzzles.

In the Shire and the Clydesdale, however, Professor Wilson finds true blacks, which apparently behave as dominants to chestnuts, and probably as recessives to bays, browns, and greys.[3]

With regard to chestnuts, it seems likely that several genetic types may exist. Mr. J. B. Robertson has pointed out that the dark or liver chestnut behaves as a dominant to the light or yellow chestnut.

To the practical breeder the question of coat-colour is a minor consideration, except, perhaps, in a few fancy breeds where certain colours are more popular than others. In the thoroughbred, at all events, a good horse is of any colour. A much more important question is: Can he win the Derby?

Coat-colour and Racing-power.

Generally speaking, coat-colour and racing-power do not seem to bear any sort of relationship to each other, being apparently inherited quite independently. On the other hand, evidence is gradually accumulating which suggests that, *in certain strains*, there is a partial coupling of coat-colour and racing-power.

For instance, the famous St. Simon was a homozygous bay that never threw a chestnut. On the other hand, five of his most distinguished sons—Persimmon, Diamond Jubilee, Florizel II., St. Frusquin, and William III.—were all heterozygous bays and browns that threw chestnuts. These chestnut grandchildren of St. Simon have so far proved themselves to be much inferior in racing-power to their bay and brown brothers and sisters. Thus, while these chestnuts have between them only won two classic races, their bay and brown brothers and sisters have between them won fifteen classic races, and are only about twice as numerous.

Another interesting point under investigation is the apparent partial *tripling* of brown coat-colour, high racing-power, and female sex in St. Simon's own offspring. St. Simon's brown fillies proved themselves to be strikingly superior in racing-power to the bay fillies, the brown colts, and even to the bay colts, a few individuals of which were extraordinarily good. This is the more remarkable when we consider that in racing colts have many advantages over fillies.

It seems possible that the elucidation of such an apparently trivial thing as

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[1] See *Proc. Roy. Soc.*, 1906, B, vol. 77, p. 388.

[2] *Mendel Journal*, No. 2, 1911, p. 89.

[3] *Proc. Roy. Dubl. Soc.*, xii. (N.S.), No. 28, 1910, p. 337.

coat-colour may help to throw light on the more complicated question of the breeding of a classic winner.

Homozygous Hunters.

It is generally admitted that the most useful type of light horse is the hunter. Recently Professor Cossar Ewart and myself have drawn up a scheme of experiments in horse-breeding for the use of the Board of Agriculture, the object being to make a line of homozygous hunters. At present there is no such thing as a pure-breeding hunter; our studies have been mainly based on the thoroughbred 'chaser as probably the most suitable material upon which to work.

Our investigation of the Stud-Book and Racing Calendar to find suitable animals with which to experiment has led us to the discovery of the existence of homozygous 'chasers, though in very few numbers. After eliminating many hundreds of heterozygous and doubtful animals, we have found five mares and three stallions, which, when bred together, have given nothing but horses of the 'chaser type, as tested on the racecourse and at the stud.

In view of this fortunate find of what might perhaps be called a 'chaser 'pure line,' we have recommended the Board of Agriculture to purchase some of the offspring of these animals in order to increase the 'pure line,' and we hope that this experiment will help us to solve the problem of the making of a homozygous hunter.

2. *Aboriginal Races and little-known Breeds of Domestic Sheep.* *By* H. J. ELWES, *F.R.S.*

3. *The Inheritance of Milk-yield in Cattle.* *By* Professor JAMES WILSON.

Before any theory as to the inheritance of milk-yield can be formed, it is necessary to find how yields can be reduced to the normal, because individual yields are frequently abnormal. A normal yield may be taken as that in which the next calf is born about twelve months after the previous one. Apart from illness (and cases in which it occurs must be eliminated), the chief causes of abnormality are :—

(i) Time of calving.
(ii) Food and shelter.
(iii) A prolonged lactation.
(iv) A shortened lactation.
(v) The cow's age.

When these causes of abnormality have been allowed for, it is found that full-sized cows fall into three grades, viz., cows that give approximately from 500 to 600 gallons of milk a year when of mature age, cows that give from 650 to 850, and cows that give about 1,000. The two extreme grades are approximately 'pure,' while the middle grade is an intermediate hybrid between the extremes.

4. *Commercial Ovariotomy in Pigs.* *By* F. H. A. MARSHALL *and* K. J. J. MACKENZIE.

5. *Temperature Variations during the Oestrous Cycle in Cows.* *By* F. H. A. MARSHALL *and* K. J. J. MACKENZIE.

6. *The Fixation of Nitrogen by Free-living Soil Bacteria.* *By* Professor W. B. BOTTOMLEY, *M.A.*

In a paper read before the Sub-Section last year under the above title, experiments were described showing that the bacteria Azotobacter and Pseudomonas fix more nitrogen per unit of carbohydrate when grown together than when grown separately. The results were criticised somewhat adversely because it

was thought that sufficient care had not been taken that the whole of the carbohydrate had been used up in the culture solution.

To meet this criticism the experiments have been repeated with duplicate flasks, containing glucose as the carbohydrate, and the determinations of nitrogen were not made until every trace of carbohydrate had disappeared from the solutions. Cultures were made with different races of bacteria, one set of experiments having ½ grm. glucose per 100 c.c., the other set having 1 grm. Thirty-eight separate nitrogen determinations were made, and in every series the mixed cultures gave a greater increase of nitrogen fixation per unit of carbohydrate than when the organisms were grown separately. It was also found in every series the mixed cultures used up the carbohydrate more rapidly than the pure organisms. The following are the averages of the nitrogen determinations:—

	½ grm. glucose.	1 grm. glucose.
Control	0·38	0·47
Pseudomonas	1·51 (6 days)	2·48 (10 days)
Azotobacter	2·32 (6 days)	3·21 (10 days)
Pseudomonas + Azotobacter . .	3·31 (5 days)	4·76 (8½ days)

7. *Some Effects of Bacteriotoxins on Soil Organisms.*

By Professor W. B. BOTTOMLEY, *M.A.*

If well-rotted manure or a fertile soil be treated with a 0·9 per cent. salt solution (100 grm. of manure or soil to 500 c.c. of solution), the liquid extracted obtained by means of a Pukall filter has a marked effect on the growth of pure cultures of certain soil organisms. The denitrifying bacteria thrive well in such an extract, whilst the growth of the nitrogen fixers Azotobacter and Pseudomonas is inhibited. Boiling the extract for an hour destroys the toxic effect of the extract.

Erlenmeyer flasks of 300 c.c. capacity filled with Giltay's solution, diluted with (*a*) 100 c.c. distilled water, (*b*) 100 c.c. manure extract, (*c*) 100 c.c. boiled manure extract, each inoculated with 5 c.c. of a pure culture *Bacillus denitrificans* showed a displacement of liquid after two days' incubation at 30° C. of—(*a*) 80 c.c., (*b*) 100 c.c., (*c*) 50 c.c. With soil extract the figures were 25, 42, and 30 respectively. In agar tube preparations the proportions of colonies in a square inch were, manure (*a*) 20, (*b*) 65, (*c*) 16; soil (*a*) 24, (*b*) 76, (*c*) 26.

The inhibiting effect of the extract on nitrogen fixing organisms was seen by growing them on nutrient agar plates containing 50 per cent. of the extract.

——	Normal Solution	Extract	Boiled Extract
AZOTOBACTER:	Colonies	Colonies	Colonies
Manure, 1 day . . .	200	0	180
2 days . . .	540	90	580
Soil, 1 day . . .	450	50	480
2 days . . .	600	80	620
PSEUDOMONAS:			
Manure, 1 day . . .	200	0	300
2 days . . .	800	50	840
Soil, 1 day . . .	250	20	280
2 days . . .	400	100	450

These effects of manure and soil extracts on soil organisms may have some significance as regards the beneficial effect of heating soils.

SECTION L.—EDUCATIONAL SCIENCE.

PRESIDENT OF THE SECTION.—RIGHT REV. J. E. C. WELLDON, D.D.

THURSDAY, AUGUST 31.

The President delivered the following Address:—

An Educational Review.

It is my duty, as it is my pleasure, to express my cordial thanks to the Council of the British Association for the honour they have done me in asking me to occupy the Presidential Chair of the Educational Section at their annual meeting. They have remembered what I was almost beginning to forget—that I was once a schoolmaster. Yet perhaps he who has once been a schoolmaster can never entirely lose the scholastic temper or, at least, I am afraid, the scholastic manner. Some slight comfort, however, I find in reflecting that there is probably no profession which has been adopted and, I must regretfully add, has been abandoned, by so many distinguished men and women as the educational. It happened to me at one time to examine for a special purpose all the lives recorded in the 'Dictionary of National Biography'; and the number of the persons who were there stated to have been more or less constantly engaged in tuition was not less surprising than pleasing to an old schoolmaster. Apart from such persons as were born, in the proverbial phrase, with a golden spoon in their mouths, it is safe, I think, to assert that one out of every three or four eminent Englishmen has at some time or other been a teacher. Nor is this the truth in England or in Great Britain alone; it is true everywhere. Not to speak of lifelong educators or of persons whose principal work was done in education, there occur to me the names of such men as Isocrates, Aristotle, Origen, St. Jerome, Cardinal Wolsey, Erasmus, Milton, Rousseau, Thomas Paine, Dr. Johnson, Diderot, Cardinal Mezzofanti, Mazzini, President Garfield, Emerson, and Carlyle, who were all content at one time or other to make a scanty living by teaching.

Perhaps the fact that so many persons have taken up education simply as a means of livelihood is the reason why there have been so many educational failures. In no profession have good men and good women done so much lasting harm, or have done it so often without being aware of it, as in education. For an educator, like a poet, is born; he is seldom made; if he is deficient in discipline or insight or sympathy, they are hard to win by practice, harder still is it to win the passion for young souls; yet the educational profession demands enthusiasm above all other qualities, and I used sometimes to say to young candidates for office at Harrow that, unless a man honestly felt he would sooner be a teacher of boys than a Cabinet Minister, he would not be a master altogether after my own heart.

Yet the educational profession in itself, if it is not the most striking or shining in the eyes of the world, may be said to be the most inspiring and the most satisfying of all professions. It is the only profession which is naturally

and necessarily concerned with all the three elements of man's composite nature, his body, mind, and spirit. It aims immediately and instinctively at the two highest objects of human aspiration, viz., the diffusion of knowledge and the promotion of virtue. Nor does any schoolmaster rise to the full height of his own calling unless he realises that his true object is to prepare his pupils, in all their faculties and in all the relations of their after-lives, for good citizenship. I cannot help thinking that a teacher who ignores or neglects the spiritual side of his pupils falls as far short of the scholastic ideal as if he were to think little or nothing of their bodies or their minds. The educational profession, when it is rightly understood, is capable of conferring signal benefits upon the community at large. There is an Oriental apologue which tells that in a time of grievous drought, when the king had vainly called upon the wizards, astrologers, and magicians to bring down rain upon his country, one humble unknown man at last stood forth to pray, and at his prayer the heaven above grew dark with clouds and there was a great rain; the king desired to know who and what was he that had prevailed alone with God, and the answer was 'I am a teacher of small boys.'

My own qualification for presiding over the Educational Section of the British Association is not so great as I could heartily wish it to be. Yet it has been my fortune to gain some knowledge of academical education when I was a Fellow and Tutor of my College at Cambridge; of secondary education during the fifteen years in which I occupied the headmasterships of two great public schools, and these schools differing radically in type, one being principally a day school and the other almost entirely a boarding school; and finally to gain some knowledge of primary or elementary education in the last four years, when I have been Deputy Chairman of the Education Committee in the famous Northern city which is now my home. Neither the time at my disposal nor my experience would justify me in attempting to deal with the educational problem as a whole. All that I think of doing in my presidential address is to lay before you some remarks upon the present state of education in Great Britain, and more particularly some proposals which have commended themselves to my judgment for improving it in a few of its aspects. My address then will be in a sense an old schoolmaster's reverie; I scarcely dare call it anything more.

Education, as has often been said, is to-day in the air. More and more deeply the civilised nations of the world, and among them at last even Great Britain, are coming to realise that in the future the battle will be not to the swift nor to the strong, but to the highly educated. It is the nation of the highest intelligence and widest cultivation which will assert its pre-eminence in the coming days.

. But before any attempt can be made to criticise the existing educational system or want of system in Great Britain, and especially in England, it is necessary to state the principles underlying all true progress or reform in education. In the briefest possible language they are, I think, these:—

1. That every child shall enjoy the opportunity of developing in full measure the intellectual and moral faculties with which God has endowed him or her.

2. That no difference of opportunity, or as little difference as possible, shall exist between the richer and the poorer classes of society.

3. That the supreme object of education is to provide good citizens—citizens who, in Milton's stately language, will be able to 'perform justly, skilfully, and magnanimously all the offices both public and private of Peace and War.'

4. That, as the personal influence of the teacher is a potent factor in education, it is the business of the State to ensure the highest possible efficiency, not only of intelligence but of character, in the men and women who adopt the educational profession as their life-work.

It seems to me that all the educational questions of the day may naturally be ranged under these four heads. The first includes Physiology and Psychology as subjects directly bearing upon the teacher's art, the study of individual character, the size of classes, the specialisation of studies, the opportunity of self-culture, the time-table and the constituents of the curriculum, above all, the practical insight by which a teacher discerns, and the sympathy by which he or she encourages, the signs of genius or talent, even when they

are overlaid by many faults and failings in a pupil. There is no more humiliating reflection than that teachers have so frequently been blind to the promise of distinction in their pupils. Of the public schools especially it is only too true that they have been, and in some degree still are, the homes of the average and the commonplace. They have applauded mediocrity, if it conformed to the rules made by the masters for boys and the yet stricter rules made by boys for one another; they have been not only oblivious but even contemptuous of such conduct as was felt to be a departure from, if not a reflection upon, the established norm of public school life.

The second head includes such difficult matters as the *carrière ouverte aux talents*, the ladder set up from the lowest educational standard to the highest, the provision of scholarships, the equalisation, as far as possible, of the conditions under which boys and girls compete for pecuniary and other rewards, the danger of social exclusiveness in schools and colleges, and the appreciation of qualities, other than mere learning, as adapting students for their parts at home and abroad in after-life.

Under the third head, if it be granted that citizenship is, or ought to be, everywhere the educational goal, it follows that the teacher may not unfairly claim from the State the opportunity of giving such an education to children, especially in the wage-earning class, where parents are tempted to take their children away from school at an early age in the hope of making them contributors to the family purse, that it may not be hopeless to implant in them a certain knowledge, and with it that love of knowledge without which education, as soon as it ceases to be compulsory, is only too apt to become a negligible factor in the citizen's life. It follows, too, that, where the interest of the State is not wholly connected with the interest of the parent or the class or the Church, some degree of regard for the State will ultimately prove to be a not unjust condition of receiving public money.

Yet again a sense of the importance attaching to the personal and professional qualities of the teacher leads almost necessarily to an insistence upon official registration as a condition of undertaking educational work, upon the training and testing of teachers by all such means as are suitable to prepare them for their responsible duties, and upon pension-schemes for facilitating the retirement of teachers when they have lost or are losing their vigour and have earned a period of repose. For education is a science; it is exacting as all sciences are; and while the educational profession needs to be made as attractive as possible, especially in days when so many other professions enter into competition with it, and while it loses attractiveness if teachers, both men and women, are compelled to retire from it at too early an age, yet it is obviously wrong to sacrifice the many to the individual or the scholars to the teacher by obliging a school master or mistress to continue in office when he or she is no longer able to perform the duties of the scholastic calling with full efficiency.

More than forty years have elapsed since the passing of the Education Act of 1870. That Act was a signal legislative achievement; it still reflects lustre on the names of Mr. Gladstone and Mr. Forster. In the intervening years it has been subjected to severe controversy, not so much on educational as on ecclesiastical grounds. It has undergone some grave modifications at various times, especially in 1902. But after all the main principles embodied in the Act of 1870, viz., that education is a national concern, that the children are the greatest asset of a State, and that it is the interest no less than the duty of the State to provide, or to see that provision is made, for the education of all children in elementary or other schools, have not been and in all probability will not be seriously challenged.

The Act of 1870 has proved to be a great moral reform. It lifted the nation as a whole to a new level of self-respect. For the child who has acquired even such elementary learning as is popularly symbolised by the 'Three R's' is a higher being than the child who cannot read or write. The elementary school teacher, not in denominational schools alone, has been a missionary of civilisation, and, I think I may say, of Christianity, in many a dark region of many a populous city. I have been told that to the influence of the Board Schools in East London was traceable a marked advance among children in kindness to the lower animals. Any disparagement or depreciation of the Education Act of 1870 is little less than treason to the moral interests of the people at large.

But it is permissible to inquire what fresh light has been shed by the experience of forty years upon the established system of elementary education in England.

Perhaps the two dangers most evident at the present time are the tendency of the Board of Education towards bureaucratic control over all the schools coming under its jurisdiction, and the habit of imposing upon the local education authorities, whether by Act of Parliament or by ordinance of the Board of Education, a number of new duties without ensuring any corresponding increase of the public funds which are placed at their service.

It is idle, and it would probably be foolish, to resist the concentration of educational authority in the Board of Education. There are signs that the Board will before long exercise a direct influence even upon the great public schools. But who or what the Board of Education is remains somewhat of a mystery. It is too apt to mean a subordinate individual acting in the name, but without the knowledge, of his superiors.

The Board may have stereotyped elementary education overmuch; it may have laid down too rigid rules or have administered its own rules with too much rigidity; it may have set an excessive store by results which could be easily tested by examination, forgetting that the best and most lasting results of the teacher's influence are just such as cannot be easily weighed in the examiner's balances. But there can be no doubt that the control of the Board has exercised a wholesome influence upon the less satisfactory schools. It assures at least a *minimum* of efficiency. But the *maximum* of efficiency lies beyond the power of the Board. It depends upon the close, intimate, sympathetic, personal relation of the teacher to his or her pupils.

Nor again is there any doubt of the advantage arising from the gradual pressure of one and the same education authority, not only upon all schools of the same type, but upon schools of different types in the educational field. It is well that elementary schools should within certain limits exhibit something like uniformity of system; it is well, too, that the ladder by which students rise or may hope to rise from the lowest to the highest rungs of educational competency should be so set up as to make the process of climbing them no more difficult than it must needs be. But freedom, spontaneity, individualism, has been the rule in all departments of English life. No power can be more chilling in its effect upon intellectual enthusiasm than the dead hand of a code. Individualism with all its faults is better suited than the rigidity of the French or the formality of the German educational system to the hereditary genius of the English people. It is necessary, therefore, that the control of the Board of Education, while it is definite, should be as elastic as possible.

Again, the State has laid upon the local education authority the duty of supplying the necessary accommodation in elementary schools, except so far as it is supplied in non-provided or denominational schools through the agency of voluntary subscriptions. But it has scarcely taken account of the difficulties lying in the way of an education authority which can issue no precept of its own. Every Education Committee in England to-day is harassed by the obligation of persuading a body so hard-hearted as a City Council, which is naturally inclined to look upon economy with more favour than upon education. The antagonism between the schools and the rates remains constant. Happy indeed is the Education Committee in a city where the Council rises above the temptation of regarding education as an extravagance or a luxury.

The provision of free meals for hungry children is an admirable reform. For if children under the law must go to school, they cannot go with any advantage if they are hungry. But free meals cost money; and the money spent upon the meals may easily be deducted from the total sum which is spent or ought to be spent upon education.

Not less admirable a reform is the physical inspection of children in elementary schools. Educational as well as medical science has learnt that hygiene is a powerful factor in the success of schools. But it is necessary to pay for a doctor's time and a doctor's skill; and if the physical welfare of the children is improved by medical attention, it is possible that their mental welfare may be impaired for lack of money.

It must be added that, in proportion as Education Committees undertake

and prosecute the benevolent work of caring for the crippled and afflicted children of the country, their just demands upon the public purse will necessarily become more pressing.

Upon the whole I am not disposed to criticise the education which is given in the different standards of elementary schools. It is not, I think, ill adapted to the two-fold object of preparing the children for their normal duties in after-life, and of offering to especially intelligent children the chance of rising to a higher position than that in which they have been brought up. But no teaching, however reasonable in itself, can be properly imparted where the classes of children are too large. If I have learnt any lesson by my educational experience, it is that difficult cases—and these are the cases which try the teacher's skill—need a great deal of individual time and thought. I used to feel, when I was a schoolmaster, that there were not more than two or three of my pupils whom I did not think I could have helped and possibly saved, had it been in my power to spend sufficient thought and time upon them. It is overcrowding which is the difficulty in schools as well as in homes; and I do not believe that any schoolmaster or schoolmistress can do full justice to a class of more than twenty or at the most twenty-five small children. But this, again, is a matter of expense, and as a matter of expense it touches the rates.

Upon the whole, too, I do not regret the substitution of Education Committees for the original School Boards. It is true that the ideal picture of School Boards consisting of educational experts who cared pre-eminently or exclusively for the educational needs of their city is naturally pleasing to the imagination. But the School Board, with its power of invading the public purse, lent itself to friction with the civic authority. At present the Education Committees connect the education of a city by a direct personal chain with its civic administration; and if the civic element upon the Education Committees should ever seem to fail in educational knowledge or interest, the opportunity of co-opting educational experts, and among these experts men and women who might often shrink from the ordeal of a hotly contested election, would seem to afford a sufficient guarantee against indifference.

But after some careful consultation with persons who in Manchester and elsewhere have studied for many years the problem of public elementary education, I have been led to the conclusion that the reforms needed at the present time are principally the following:—

The control of the Board of Education over local education authorities has become too strong and too stringent. It is probably stronger and more stringent now than it has ever been since 1870. It would be wise, I think, to leave or to place greater administrative power in the hands of the local education authority. Local authorities understand local needs. So long as they do not depart from the general principles laid down by the Board of Education, they should be free to expend each its share of the public monetary grant in the way which they hold to be best for their own communities.

I see no need for a dual system of inspectors in elementary schools, and I think it tends to the interference of H.M. Inspectors with details upon which their judgment is sometimes more confident than their knowledge is profound.

It is difficult in speaking of inspection to refrain from all allusion to the notorious circular letter which was issued some time ago in the name of Mr. Holmes. That letter was not, I think, so wrong in sentiment as in language. Inspectors chosen from the ranks of the elementary teachers may be deficient in breadth of sympathy, as other inspectors educated in the ancient universities may be deficient in practical experience. It is much to be hoped that the unnatural contrast between the antecedents of two classes of inspectors will pass into the background, and that the duty, which lies upon all education authorities, of appointing the best men or women as inspectors, whatever any one's antecedents may have been, will regulate all appointments in the future.

The period of a child's school-life is now too brief. There should, I think, be a universal *minimum* age at which children may leave school. It should probably be fourteen years. But whatever that age is, it should be absolute. It should be wholly independent of local by-laws, of the passing of standards, or of attendance at school before the age of fourteen.

The question of evening schools is fraught with difficulty. To make attend-

ance at such schools compulsory would be to run a serious risk of over-pressure. It is probable that sympathetic co-operation between local education authorities and the employers of labour in the locality will in this matter afford the best hope of success. For it is to the interest of the employers themselves that their employees should not cease to improve themselves in knowledge as soon as they leave the elementary schools.

The need of the local education authority for increased financial help out of public funds was recognised, I think, in Parliament during the debates on the last Education Bill. The State cannot make fresh demands upon the education authorities without granting them fresh funds. Yet there can be little doubt that the feeding of necessitous children and the care of the epileptic, feeble-minded, and crippled children will soon or late become duties imposed by Parliament on all local education authorities.

Lastly, the connection between the elementary school and the university or the technical school should be made complete. At present the elementary school provides education for children up to their fifteenth year. The university or the technical school does not admit pupils under sixteen years. But education, when it is once broken, is hard to resume. The educational system, if it is to be efficacious, must be continuous.

Upon the difficult and delicate subject of religious teaching in elementary schools I have so far scrupulously refrained from touching. It would not, I think, become me to make more than these two remarks:—

1. That religion is in the long run the most potent support of morality; religious teaching is, therefore, a necessary element in every sound educational system; and any religious teaching, if it be but the belief in an Almighty Power, is far better than Secularism or Paganism. But it is the State alone – not any Church or religious body, but the State alone—which can ensure the attendance of all children at religious teaching, subject of course to exemption on conscientious grounds.

2. That if it is or may be held to be the interest of the several Churches to educate their children in watertight compartments, so that no child shall come in religious contact with any child not of the same creed as his own, that is not at all the interest of the State. The State needs that its citizens shall have learnt to know and respect each other in spite of religious differences, to rub shoulders together, and to co-operate with each other for the public good. It needs citizens who are capable of judging even religious questions not without reference to the welfare of the body politic. It is probable therefore, and I cannot say it is unreasonable, that the State, while freely allowing the different religious bodies, if they are able and willing, to provide for the religious education of their own children, will require some mitigation of religious differences in the schools supported out of the public exchequer or out of the local rates.

A public elementary system of education then must be complete in itself, so far as it prepares children physically, intellectually, and morally for the affairs of life. But it must not lose sight of the possibility that some, and those the most promising, of the children educated in elementary schools will deserve to rise to a higher than an elementary educational standard.

It is probable that the ascent of pupils from one class of school to another will become more usual in future years. This ascent will be effected or facilitated, as to some extent it already is, by the provision of free places, bursaries, exhibitions, and scholarships. Even now boys educated in elementary schools have attained the highest honours in the ancient as well as in the modern universities. Some such boys have won admission to the public schools, and among these schools to boarding schools as well as to day schools. Whatever amount of social exclusiveness may still apparently linger in that most truly democratical of English institutions, a public school, it seems to me impossible that in a democratical age there should ultimately remain any school which will not open its doors to pupils who are drawn from every social section of the community. In the education of girls, the schools of the Girls' Public Day School Company and other similar schools, whether publicly or privately governed, have done much to mitigate, if not to dissipate, the social differences among girls living in the same locality.

But the agencies by which children of comparatively poor parents have in

the past been enabled to receive an education in the schools, and indeed in the universities, of the rich are, I am afraid, coming to be gravely abused. Scholarships and exhibitions were designed to remedy the disadvantage of the poor, not to accentuate the privilege of the rich. To confer pecuniary rewards upon boys and girls whose parents can well afford to dispense with them is to foster a double abuse. It is to spend money where money is not needed, and to withhold money where it is needed. Yet in the public schools, and to some extent in the universities, scholarships and exhibitions tend to become the perquisites of the rich. In the field of secondary education the competition for scholarships and exhibitions has become so severe that scarcely any boy in the examination for them stands a chance of success, except at the cost of three or four years spent beforehand in an expensive preparatory school. But as rich boys are the only boys whose parents can afford this preparatory expenditure, it follows that rich boys are generally the successful candidates for scholarships and exhibitions. The evil is scarcely capable of exaggeration. It were bad enough that a rich boy, if he competed on equal terms with poor boys, should obtain a pecuniary reward which they do, and he does not, need for educational purposes. But when it is the rich alone who enjoy the opportunity, or the most favourable opportunity, of winning the pecuniary rewards which were justly intended for the poor, a case for drastic reform seems to be made out.

At the ancient universities the sons of rich parents, although they are generally eligible for such prizes as scholarships and exhibitions, do not possess the same advantage in competing for them. More, too, has been done in the universities than in the public schools to provide means by which the sons of rich parents may enjoy the distinction without the emolument of a scholarship. But it is an urgent matter that alike in the colleges of the universities and in the public schools the pecuniary benefits, by which alone deserving boys can rise above their hereditary surroundings, whether bursaries, exhibitions, or scholarships, should be strictly confined to the sons of the poor.

Here perhaps it is permissible, as it is certainly natural, to enter a protest against the established tyranny of examinations. Examination was once the obvious remedy for favouritism. But a mere examination in knowledge can never test some of the highest qualities which fit men and women for the service of the State. In India even more than in Great Britain the failure of examinations is conspicuous. A facility for answering questions upon paper is easily associated with grave defects of intellect and character. In proportion then as favouritism ceases to be a public danger, examinations will, I think, lose something of their fatal authority. It is difficult to doubt that in the future candidates for public office will be required to pass a qualifying examination, but that the election will, at least in some degree, turn upon qualities which are not so easily tested by examination in writing.

Nor is this the whole evil. There is only too much danger that examinations may create a false ideal of educational success. The object of all education, as I have said, is to prepare pupils for the civic duties of mature life. It is not the intellectual attainment of the young at the age of thirteen or eighteen or even twenty-two, it is rather the service which they render to the State in the maturity of their powers, which is the proof of the teacher's influence upon their lives. The preparatory schools which have become such important features in the field of secondary education have done much useful work. The decadence of bullying and perhaps of other evils in public schools is largely due to the elimination of quite young boys from public-school life. The years of a boy's life from nine to twelve, but not, I think, to a later age, may well be reserved for the preparatory school, as the years from thirteen to eighteen for the public school. But the forcing process which is sometimes applied to young boys in preparatory schools, not only in their lessons but in their games, is fraught with serious peril. A preparatory-school master, if he thinks of his own school alone, may do even worse harm than a public-school master by sacrificing the future of his pupils to the present. When I was a headmaster, I knew of one preparatory-school master who tried to win boys to his school by offering what he called pre-preparatory scholarships to boys of eight or nine years of age, in the hope that these boys might after a time serve as advertisements for his preparatory school by winning scholarships from it at the public schools. But preparatory-school masters are not alone in fault. It is, I am afraid, easy to

think of headmasters who have attained what I can only call an ill-deserved reputation, because their pupils have won numerous scholarships and exhibitions upon leaving school, when those same pupils had been mentally exhausted in youth, and their after-life in no way answered to the promise of their early days. 'By their fruits ye shall know them'; but the fruits of a true education are seen not in the spring but in the summer or the autumn of a well-spent life.

It is with reference to the final goal of education that the subjects suited to the secondary curriculum must be judged. If the possible subjects are too many, it becomes necessary to strike the balance between utility and culture, and so to decide which subjects are indispensable and which may fairly be subordinated or postponed.

The most striking change which has come over secondary education has arisen from the number of subjects now claiming admission to the curriculum. Scarcely more than fifty years ago the headmaster of a public school was almost at his wits' end to fill up the time-table of his pupils. Dr. Arnold was appointed to the headmastership of Rugby in 1828, and Dean Stanley says of him that 'he was the first Englishman who drew attention in our public schools to the historical, political, and philosophical value of philology of the ancient writers, as distinguished from the mere verbal criticism and elegant scholarship of the last century.' He adds that 'besides the general impulse which he gave to miscellaneous reading both in the regular examinations and by encouraging the tastes of particular boys for geology and other like pursuits, he incorporated the study of modern history, modern languages, and mathematics into the work of the school, which attempt, as it was the first of its kind, so it was at one time the chief topic of blame and praise in his system of instruction.' Other public-school masters followed suit, but they followed slowly. What the system of education had hitherto been may be judged from Malim's 'Consuetudinarium,' which specifies no subject of instruction except Latin, with a little Greek grammar in the sixth and seventh forms. The dancing-master was a more ancient and more honourable figure in some public schools than any mathematical-master. Mathematics, in fact, were not introduced into Eton until 1836. Other subjects in addition to the classics came even later.

But within the last fifty years, not only mathematics but the English language and literature, foreign languages, natural science in its various branches, history, and geography, have become competitors with the ancient classical languages for recognition in the curriculum of public schools. There is no one of them which is not worthy of such recognition. But the average intelligence of a public-school boy has remained the same, and the average length of his life in the public school has been diminished by as much as one-half. It has become necessary therefore to make a selection between the subjects which might well, if they could, be taught to all boys alike. Nor is this truth less applicable to girls than to boys.

It may be thought that not enough attention has been paid to the order in which particular subjects are taught. The number of subjects imposed upon a child of ten to twelve years is at times not less alarming than forbidding. Psychology suggests the adaptation of particular subjects to the awakening of particular powers at different ages. Even in literature there is a natural affinity which is too often disregarded between books and the ages at which they ought to be read. How many children have read 'The Pilgrim's Progress' at too late, or have read 'Hamlet' and 'Paradise Lost' at too early, an age for true appreciation! In literature as elsewhere discrimination is the watchword of educational success.

From these considerations it seems to follow that the scientific educator must choose certain subjects as the basis of secondary education, and I venture to think that these subjects should be as nearly as possible common to boys and to girls. Other subjects can be left to the choice of particular students at a later period of their lives. Not all subjects are possible or useful to all students. Soon or late, then, uniformity of teaching must give way to specialisation.

Yet education loses a great part of its value unless it ensures to all educated men and women what may be described as a common educational property. It is desirable that they should not only all learn some things which are worth knowing, but that they should learn the same things. For upon community of information or of interest depends the sympathy of all educated people.

If one person knows nothing but French, a second nothing but chemistry, and a third nothing but mathematics, it is evident that they possess no common stock of knowledge; no interchange of sentiments or ideas is possible between them. All sound secondary education then postulates a broad basis of common knowledge, or, in other words, a certain body of knowledge which is possessed by all students in common. Upon this basis must be built a superstructure varying in accordance with the needs or capacities of the pupils.

What then are to be the basal subjects of secondary education?

They must be few, they must be suitable to the tender years of school life, they must be practically useful, and yet they must possess the element of culture.

Religion, of course, will be one, for it is the paramount factor in the discipline of character.

The study of mathematics possesses the unique merit that it shows what proof is; it distinguishes certainty from probability; it evidences the narrow limits within which certainty is possible.

Natural science in its various branches is especially valuable as cultivating the faculty of observation. Scientific facts can be generally tested by experiment. It is only the pupil who has learnt at least the elements of natural science who begins to feel at home in the world in which he or she lives.

But among educational subjects the palm, I think, belongs to language, if only because language is the subject which stands, by its character as well as by its origin, in the most intimate relation to human nature. Men and women are not generally concerned with questions which can be absolutely and ultimately determined. Most questions in life are probable, but not certain; it is 'probability,' as Bishop Butler says, which is 'the very guide of life'; and such, too, are generally linguistic questions. They do not admit of certainty, they can be decided only probably, and the decision of them requires tact, judgment, and feeling. That is the reason why the school of languages is called *Literæ Humaniores* at Oxford. Language is the one pre-eminently human or humane study.

But it is evident that different languages, as instruments of education, may stand on different grounds.

English boys and girls cannot afford to be ignorant of their own language or literature or history. For they use every day the English language; their minds are fed by English literature; and the past history of their country affords them guidance in the present and the future.

Foreign languages on the other hand are practically useful in the relation of Englishmen to other nations. It is possible that these languages will become less important as the English language spreads over the world. But for the present at least a knowledge of some modern language is desirable, not only as a means of mental discipline but also as a means of intercommunication. One modern language at least, then, may fairly be regarded as entering into the basis of secondary education; and that language at the present time would naturally be French, although much is to be said for German, and something for Spanish.

The educational difference between languages and other subjects is, I think, more clearly marked than the difference between one language and another. Whatever intellectual benefit is derivable from an ancient language may in a greater or less degree be derived from a modern language. But it has been shown by many writers, as, for instance, by J. S Mill in his Rectorial address at the University of St. Andrews, that a classical language, like ancient history, if only in virtue of its remoteness from present interests, possesses some educational advantage, and this advantage is particularly clear when an ancient language stands in the relation of Latin to the Romance languages or to any considerable number of languages in actual use. Latin must therefore enter into the general curriculum, and I attach great value to keeping Latin as a subject of general study in secondary schools. For the prejudice of parents in the present day against dead languages is unhappily strong. I have spent much of my time in trying to convince parents that their sons would be better educated by the study of Latin, if not of Greek also. It is for this reason that I regret the somewhat pedantic insistence upon pronunciation of Latin according to a method which, whether it be historically correct or not, will certainly tell against the universality of Latin as a subject of study. I do not believe the modern pronun-

ciation is correct; but whatever may be the philological value of that pronunciation, I feel no doubt that the artificiality, as it seems to parents, of the non-English way of pronouncing Latin will, like the artificiality of the Greek type, create a prejudice in many minds against the study of Latin. Nor is this all; for the study of Latin loses a good deal of its practical value if every or nearly every Latin word is by the method of its pronunciation divorced from the corresponding word in English. It does not really matter in the present day how Latin is pronounced. Latin is no longer a medium of oral communication, even amongst scholars. The vital matter is that Latin should be one of the subjects constituting the permanent basis of education in all secondary schools.

Apart from these subjects, viz., religion, English, French, Latin, mathematics, and natural science, there is none, I think, which can justly claim a part in that knowledge which I have ventured to describe as the common property of all boys and girls in secondary schools. It is, in my judgment, a happy circumstance that preparatory-school masters have practically decided to relinquish the teaching of Greek, and to concentrate their efforts upon such subjects as form the natural basis of secondary education.

But upon the basis so constituted the teacher will try to erect a varying superstructure, by offering as wide a range as possible to individual tastes. For if the secret of education lies in discovering what a pupil's capacity is, and so in helping him or her to cultivate it, education must pass soon or late from the common basis of subjects to specialisation. It is not my business now to decide how the principle of specialisation should be applied. That is a problem which the individual school master or mistress must work out for himself or herself. The two points upon which I would venture to insist are the common educational property, and the wide elasticity allowable as soon as this common property has been gained. But I am of opinion that, while specialisation is allowable and desirable in the later years of a boy's or girl's life, it should never be complete. The dying out of double degrees in the universities of Oxford and Cambridge has always seemed and still seems to me unfortunate. For it means that nobody now gets so thorough an education as was possible if the student applied himself through his life at school as well as at the university both to classical and mathematical studies. The amplification of the several studies may have justly affected the course of education in the universities; but it is my deliberate conviction that a boy or girl, whose time is wholly or mainly given to one subject only during school life, loses a signal opportunity of obtaining a generous education

It is tempting to me as an old schoolmaster to linger on the field of secondary education. But the limit of time at the disposal even of the President of a Section forbids me to think of adverting to more problems of secondary education than the two following :—

Public opinion has always been divided in the education, whether of boys or of girls, between boarding schools and day schools. Adam Smith in his 'Theory of Moral Sentiments' went so far as to say 'that the education of boys at distant great schools, of young men at distant colleges, as well as ladies in distant nunneries and boarding schools, seems in the higher ranks of life to have hurt most essentially the domestic morals, and consequently the domestic happiness both of France and of England.' The complete severance of a boy or a girl, except during the holidays, from parents and family is evidently or may evidently prove to be an evil. It tends to undermine some of the graces of character, it produces in boarding schools the same defects, but perhaps, too, the same merits, as are observable in celibate religious institutions, like monasteries and nunneries. There is too much tendency, especially among parents of the wealthy class, to feel that they have done their duty to their children in paying their children's school fees, and to hand them over to the schoolmaster or the schoolmistress without any thought of the influence which the home ought to exercise upon young lives. It is reasonable to suppose that, if the sense of parental responsibility could be revived, fathers and mothers would be more anxious than they are now to keep their children at home in the early years of their lives. Preparatory day schools, at least in the great cities, will, I think, acquire a growing importance. But at present the choice between boarding schools and day schools for boys, and in a less degree for girls, is largely determined by pecuniary considerations. For in truth the great public boarding schools are

such characteristic features of English life among the upper social class, they have gathered to themselves such a wealth of tradition and influence, they are so deeply rooted in the confidence and affection of the English-speaking world, that it would be difficult, if not impossible, to replace them. Nor can it be doubted that the education given in these schools, however rough and ready, however deficient in some respects it may have been, has yet done much, in Canning's bold ecclesiastical phrase, to produce 'a supply of persons duly qualified to serve God both in Church and State,' and has tended to foster some of the qualities by which the English race has attained its sovereign position in the world.

Again, there is the question of co-education. For if the early education of boys and girls may, as I have argued, safely proceed on the same lines, it may be held that they can well be educated together. Nor is there any valid educational reason why boys and girls should not be educated together, as they are in the United States of America. In England itself they receive their early education, and they are beginning to receive their academical education, together. It is at least conceivable that co-education throughout the period of school life may come to be the rule in day schools. In boarding schools, however, where the life is ordered on somewhat artificial principles, co-education would almost certainly create problems which would enhance the difficulties of the master or mistress. I do not therefore anticipate that co-education in schools will assume a large importance in English life.

So far I have tried to indicate a few of the problems calling for the attention of persons who are engaged or interested in secondary education. Here at least I may claim to speak with some degree of experience. It is with hesitation that I approach the subject of the highest education as given in the universities, especially in the universities of Oxford and Cambridge.

The elasticity which is characteristic of English life has in the last half-century created a number of local universities beside the two ancient universities. It would be unwise, even if it were feasible, to aim at assimilating the ancient and the modern universities. It is not impossible that the modern universities will lead the way in educational reform. The dead hand of the past lies heavily upon the historical seats of learning. No fact of educational history seems to be stranger than the inability, perhaps I ought to say the unwillingness, of the universities to reform themselves. It might have been anticipated that a home of learning would be a seat of powerful reforming energy. It has not proved to be so. The universities of Oxford and Cambridge have been reformed more than once, but the reform has come from without and not from within. Whether the present Chancellor of the University of Oxford will succeed in persuading the university of which he is the distinguished head to reform itself without waiting for the action of Parliament is a question on which it would be unsafe for me to venture an opinion. But his plea for reform is itself a proof that reform is needed. It will not, however, be unfitting that I should insist upon the value, and the ever-increasing value as I think, of the work belonging to the modern universities in the great cities of the land—can I be wrong in saying pre-eminently to the Victoria University of Manchester? History seems to suggest that the association of a seat of learning with a great centre of industry may produce the best results, in so far as it imparts culture to industry and practicality to learning. The modern universities have appealed with striking success to the generous instincts of local patriotism. They have shown the possibility of gathering an earnest body of teachers, and through them of imparting a genuine intellectual culture to a large number of students, without imposing artificial restrictions upon their studies. They have proved the possibility of uniting men and women upon equal terms in the same academical institutions. The Victoria University has aimed with conspicuous success at solving the difficult problem of uniting the teachers who belong to the different branches of the Church in a common faculty of theological learning. In some of these respects, if not in all, the universities of Oxford and Cambridge will probably follow suit. It can scarcely be doubted that the time is not distant when Oxford and Cambridge will open their doors to students without insisting upon the so-called compulsory study of the Greek language. I speak as one who more than a quarter of a century ago argued against the policy of requiring some knowledge of two dead languages

from all students as a condition of entrance into the ancient universities. Such a requirement may have been possible, and even reasonable, when educational subjects were few. It cannot be maintained when those subjects have been greatly multiplied. For the result is either that the study of two dead languages, or at least of one among them, is little more than a farce, or that it causes an unhappy disturbance at a critical period of a boy's intellectual life. Nay, I should be tempted to say that to boys who have received their education on the modern sides of public schools the obligation of acquiring some smattering of Greek knowledge is both a farce and a nuisance.

Nobody feels more keenly than I the intellectual benefit of studying the Greek language and literature. It is my sincere hope, as it is my firm belief, that, when Greek rests upon its own intrinsic merits as a factor in human culture, the study of Greek, if it is less general, will not be less profound than it has been. But times change, and compulsory Greek as a universal subject is unsuitable to the present time, not because it is useless in itself, but because it bars the way more or less against other studies which are still more important. The universities enforce their law upon secondary schools. The schools must teach what the universities require; they cannot teach, or they can only teach within a fixed limit, what is not required at the universities.

In my own mind, however, the abolition of compulsory Greek is only a step to a change in the intellectual atmosphere of the universities. I hope that Oxford and Cambridge will cease to insist upon Greek; but I hope that, when they cease to insist upon Greek, they will require from all students the evidence of some serious learning in some subject or subjects of higher education. Nobody who is conversant both with the ancient and with the modern universities can fail to be aware of the difference in their tone. The atmosphere of a modern university is intellectual. Men and women come there as students; they come to learn, and they do learn. At Oxford and Cambridge the atmosphere is much more social; and the number of undergraduates who can in any sense be called serious students is but a fraction of the undergraduate body. The time is, I hope, approaching when a degree conferred by the universities of Oxford and Cambridge even upon a Passman will be a certificate of a certain definite proficiency in some recognised subject of academical study. For it seems to me that the ancient universities in conferring degrees without an adequate guarantee of knowledge are largely responsible for the indifference of English society as a whole to the value and dignity of learning.

No doubt there is force in the plea that the universities cannot afford the pecuniary loss which would result from the policy of excluding Passmen, or of pressing hardly upon them. It may be answered that no pecuniary consideration can justify a university in ceasing to be primarily a learned body. But women students are more earnest than men; and if the universities grant degrees, as I hope they will, to women equally with men, they will probably find that they will receive as much money from the addition of the serious students, who will then belong to them, as they now receive from those students who are not serious at all.

The universities of Oxford and Cambridge have made frequent appeals for pecuniary support. Education—especially scientific education—is expensive, and it tends to increase in expensiveness. But I have sometimes wished that, before money is poured into the exchequers of the universities, a Commission, composed of men who are fully sympathetic with academical culture and yet have been trained in the habits of business, could issue a report upon the use now made by the universities and by the colleges of the funds which they severally command. I am of opinion that such a Commission would not prove unable to suggest the possibility of large economies which might be carried out without impairing the efficiency of the universities as seats of learning, or even of the colleges as homes for the students whose proper object in their academical life is to acquire learning.

All that remains is to offer an opinion in some few brief words upon some subordinate matters of academical education.

There is something to be said in favour of, but more perhaps to be said against, the proposal for two concurrent kinds of degrees, the degrees of Bachelor and Master in Arts and of Bachelor and Master in Science. For the academical degree possesses a recognised advantage as setting one and the same hall-mark

upon all persons who possess it. It would be less distinctive, and therefore less valuable, if its significance were not uniform. Nor does there seem to be any valid reason against conferring the degree of B.A. and M.A. upon all students who have shown themselves to possess a certain uniform culture, whatever special study or studies they may have pursued and whatever degree of excellence they may there have attained, after satisfying the requirement of culture demanded from all persons who aspire to the possession of an academical degree.

Again, it is desirable that every university should be free from theological restrictions. I look forward, therefore, to the time when the universities of Oxford and Cambridge will recognise Nonconformists no less than Churchmen as eligible, not only for degrees, but for Lectureships and Professorships in the Theological Faculty. There is a broad distinction between the study of theology and the profession of theological beliefs. It is no hardship upon a student that he should be examined in theology so long as he retains his complete freedom of theological opinion. That theological recognition should be accorded to none but persons of particular views upon theology is in conflict with the highest interests of theological learning. At present the universities of Oxford and Cambridge are the close preserves of the Church of England; the natural result is that the modern universities tend to become the preserves of Nonconformity; and neither class of university is benefited by the consequent one-sidedness of theological study.

The co-education of men and women in the universities, whether ancient or modern, is already an established reality. The only difference is that co-education is recognised in the modern, and is not recognised in the ancient, universities as necessarily leading to an equality in the matter of degrees. The real objection to placing women on an equality with men in their relation to a residential university is the difficulty of finding room for a number of female as well as male students within the precincts of the same university. On that ground alone there is some advantage in universities or colleges for women only, such as the Royal Holloway College; but experience has shown that colleges for women do not flourish except in close relation to a university in which the education of men is carried on, and I feel no doubt that the granting of academical degrees at Oxford and Cambridge to women as well as to men is merely a question of time.

No critic of the ancient universities, and certainly no one who has spent some happy years there as an undergraduate and a Fellow, can forget that the social as well as the intellectual side of the life is a part of its privilege and benefit. But that social intercourse would lose something of its value if students of different classes and different creeds did not mix freely. It is too often forgotten, in the zeal for ecclesiastical propaganda, that one element of education lies in teaching people who do not agree to work together. To make the least, and not the most, of personal differences is a factor in the life of universities. It is for this reason that I do not look with any great favour upon the institution of special colleges set apart for Churchmen or for Nonconformists or for men of poor and humble circumstances. It is better that such students should as far as possible associate with other students; for in such proportion as undergraduates of religious feeling or of strenuous self-denying character are educated by themselves, there is a diminution of their valuable influence on the mass of the undergraduate body. There might as well be Conservative Colleges and Liberal Colleges as colleges of a special and exclusive theological character.

Colleges are expensive features of academical life, and they tend to become more expensive; but the expense is justified by the benefit which the students may receive from the influence of their teachers upon their lives. But if colleges are to exist as integral parts of the university, there should be a sufficient number of Fellows and tutors living within their walls. No feature of modern life at Oxford or Cambridge is more pitiable than the spectacle of a married don coming into his college at a late hour of the evening, with his carpet-bag in his hand, to fulfil the statutory obligation of sleeping within the walls. No deep personal interest or influence of a tutor in the lives of his pupils is possible in such circumstances as these. If only it were possible to defer the opportunity of marriage until a man has rendered some years of service by residence within the walls of his college, and then to grant it only to men whose service the college

wishes to retain, the collegiate life of the ancient universities would be less likely to lose its effective value.

But when all is said, how great is the charm of the ancient English universities! They are unique; they exercise a lifelong spell upon pupils who have spent three or four years within their ancient walls; they foster, even if unconsciously, a noble sense of patriotic duty; they haunt the memory; they are fruitful in high and generous and sacred inspirations.

What is the spirit of a university? How is it born? How does it operate? Why is Cambridge in a special sense the home of mathematics, and Oxford of letters? Why is it that Oxford finds so many, and Cambridge so few, representatives upon the public Press? Cambridge, it seems, has played the greater part in the thought, and Oxford in the life, of the nation. But why is it that Cambridge has given to the world sons more famous, it may be, than any whose names belong to the sister university—Bacon, Newton, Cromwell, Milton, and Darwin? Why, above all, is Cambridge in so pre-eminent a degree the university of the poets? Such names as Milton, Ben Jonson, Herrick, Cowley, Dryden, Byron, Gray, Wordsworth, Tennyson belong to Cambridge alone. Nothing can replace, nothing perhaps can greatly affect, the relation of the ancient universities to the country whose ornaments they are. What is needed, and will be more and more needed as democracy extends its powers, is to enhance the strength of the influence which the universities exercise upon the national life at large.

So I bring this imperfect review of the educational problem in its present aspects to a close by insisting in two or three final sentences upon the supreme dignity of the teacher's profession. The man or woman who elects to become a teacher chooses a great responsibility. It is well that teachers should be disciplined for their calling by a system of training in the educational art. The theory of education as set forth in the writings of great educators like Comenius, Froebel, Pestalozzi, Arnold, Thring, Fitch, and many others, should be well known to them, even if the practical side of education is best learnt, or can only be learnt, by practice. Education needs the best men and the best women. It must, therefore, be set free from such bonds as have tied it to the clerical profession; nor can I think it is ever well to exact religious tests of teachers, for tests are apt to affect tender consciences alone. If only teachers are asked whether they wish to give definite religious instruction or not, and are subjected to no drawback or disadvantage if they choose not to give it, I think the teachers in all grades of schools may be trusted not to abuse their sacred opportunity. They must teach their pupils to love learning and virtue, and to love them for their own sakes. They must remember that it is the personality of the teacher which is the chief source of his or her influence on the pupils. They must ever be trying to make themselves more and more worthy of their responsibility. 'Thou that teachest another, teachest thou not thyself?' must be the motto of their daily lives. But where the educational profession is one in all its branches, where it is actuated by a due sense of responsibility, where it aims in season and out of season at cultivating habits of self-respect, self-sacrifice, patriotism, and religion in the children who will be the citizens of the future, where it remembers that the supreme triumphs of educational skill are good men and women, good fathers and mothers, good servants of the State and of the Church, there is no ground of fear for the country or the Empire.

The following Report was then read:—

Report upon the Overlapping between Secondary Education and that of Universities and other places of Higher Education.—See Reports, p. 216.

FRIDAY, SEPTEMBER 1.

The following Papers and Reports were read:—

1. *Discussion on the Place of Examinations in Education.*

(i) *Examinations. By* P. J. Hartog, *M.A., B.Sc.*

'The public demands that persons on whose services it relies, but for whose failures it cannot be compensated, as by a business man who fails to fulfil his contract—that these should produce some certificate of competency based on an examination, and often on a series of examinations beginning in childhood and prolonged into early manhood and beyond.' This sentence, which I venture to quote from a recent address of my own,[1] explains why the outcry against examinations, both from men of sense and from sentimentalists, during the last twenty-five years has proved, on the whole, futile. It is true that 'payment by results' has been abolished in the elementary schools, with consequences which, to some independent thinkers in educational matters, are not altogether satisfactory.[2] But in secondary schools and in universities examinations multiply incessantly. 'One gets involved in the machinery and feels hopeless,' a young university teacher wrote to me recently. The whole tendency is for higher examinations to increase. Is it not, then, of the first importance that we should ask what our present examinations do really test, what kind of examinations should be utterly rejected and cast out, what are capable of improvement, and how they may be improved? The British Association has a great scientific tradition. Might it not assist in applying scientific method to the examination of examinations? The suggestion which I made recently that the subject deserved inquiry by a Royal Commission, aided by scientific assessors, has been supported by Lord Cromer, by Professor John Adams, Principal Miers, Professor M. E. Sadler, and Dr. Schuster, and by a large body of public opinion. My plea is strengthened by the recent movement in favour of placing all patronage for public appointments in the hands of the Civil Service Commissioners.

I suggest that a British Association Committee should be appointed to sketch out a plan of inquiry into the methods and efficiency for their purpose of public examinations, with special reference to the influences of such examinations on the previous education of the candidates.

I would ask such a Committee, if appointed, specially to consider the following propositions:—

(*a*) That every examination ought to be regarded as a capacity-test, *i.e.*, that it should be so devised that one may be able to state clearly in words that a person who has passed it *can do* such or such a thing (*e.g.*, can write legibly, can read clearly and intelligently, can add and multiply correctly, can understand the non-technical portions of a French newspaper);[3] (*b*) that certain further portions of the educational field should be as completely protected from the ordinary examination tests as those concerned with moral training already are so protected.

(ii) *The Place of Examinations in Education.* *By* Miss S. A. Burstall, *M.A.*

The subject of examinations has been dealt with by the Headmistresses' Association since 1907. The sub-committee it appointed has been at work to ascertain facts and to consider possible reforms. The Association feels strongly the injury caused to girls' education, and in some cases to their future powers. The following resolution was carried at the 1909 Conference: 'That this Conference disapproves of external examinations for girls under sixteen years of age,

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[1] *Examinations in their Bearing on National Efficiency.* London: Hugh Rees, 1911.

[2] Cf. Mr. D. C. Lathbury's article on 'Our Elementary Education—Are we on the Right Road?' in the *National Review* for March 1911.

[3] I should exclude from capacity-tests such tests as merely show the power of repeating or writing out matters learnt by heart.

and invites all members of the Association to co-operate in discouraging pupils from entering for them.'

Possible Reforms.—Acting teachers should take part in the administrative work of Examining Boards, as in the system of the Joint Matriculation Board of the Northern Universities.

Question of School Record.—The difficulty of using this in all competitive examinations.

The following resolutions were carried at the Headmistresses' Conference of 1911: 'That this Conference regrets the increasing difficulty of University Scholarship Examinations for girls, and asks the principals of colleges for women at the universities to give the matter their serious attention with a view to lessening the strain of preparation and in examination.' 'That in Matriculation examinations credit should be given for the School Board in compulsory subjects in the case of pupils who have passed through a complete course of studies for not less than four years in a school (*a*) inspected by the Board of Education, and (*b*) periodically examined by a University Board of Examiners, (*c*) on whose staff there is a certain proportion of registered teachers.' 'That this Conference urges that it is of the greatest importance to the best type of general education that (1) the co-operation of acting teachers should be recognised and allowed in all school and matriculation examinations; (2) schools should be allowed and invited to present their own syllabuses for school examinations; (3) that in testing of science teaching inspection should be more prominent than examination, and that the notebooks covering a definite and consecutive course of work of the candidates should be taken into consideration in the awards of examinations.'

The importance of investigating possible reforms and securing a policy which may be pressed on public opinion and on examining bodies.

(iii) *The Place of Examinations in Education. By* DR. T. P. NUNN.

(iv) *Examinations and Inspections. By* MRS. JESSIE WHITE, *D.Sc.*

Jevons in 1877 defended the examination system, and said that examination was the sheet-anchor to which we must look. In the primary schools the relation of the school to the inspector has been changed by abolition of payment by results. In secondary schools the examination system judges the school by what it does for the best pupils, whereas inspection claims to consider the weaker pupils. There was a vicious alternative involved in Jevons' answer to the argument that the examination system curtailed the liberty of the teacher. It is not the single teacher but the whole body of teachers in committee that should frame the curriculum. This is not yet sufficiently recognised. The externality of the curriculum to the teachers is reflected in the method of inspection, and also the failure to recognise that the work of a school cannot properly be gauged without an attempt to estimate the general standard of attainment of the different classes. To do this inspection may require to be supplemented by examination of a special kind. The three methods of inspection are hearing lessons, questioning the pupils, and examining the exercise books. There are certain drawbacks connected with each. They require to supplement each other, and certain popular fallacies with regard to inspection need uprooting. There is need for a well-defined etiquette of inspection, and to be of real value an inspection must include a joint meeting of the inspectors and whole staff with a view to discussing the work and aims of the school. Such a meeting would secure advantages to both inspectors and teachers, and the necessity for taking part in such a meeting would frighten off from the inspectorate those who were unsuitable.

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2. *Report on Changes affecting Secondary Education.*—See Reports, p. 234.

3. *Discussion on the Policy of giving the Board of Education authority over all Exchequer Grants for University Education. Opened by* Principal E. H. GRIFFITHS, *F.R.S.*

4. *Report on the Curricula and Education Organisation of Industrial and Poor Law Schools.*—See Reports, p. 214.

5. *Discussion on Grammatical Terminology. Opened by* Professor E. A. SONNENSCHEIN, *D.Litt.*

This paper dealt with the following topics:—

(*a*) The history of the movement from 1908 to 1910-11, when it received the general approval of the eight associations of teachers represented on the committee.

(*b*) The need of a reform if the teaching of grammar is to be intelligible and effective. Evidence from the Continent and from America.

(*c*) How it has come about that different terminologies are employed in dealing with different languages. The common assumption that in order to understand properly the usages of a particular language we must re-classify these usages from a new point of view. Argument in favour of a different procedure. The limitations of the scheme.

(*d*) On what principle should a scheme of a terminology suitable to all the languages taught in schools be constructed?

(*e*) Illustrations of the advantages of the scheme of terminology drawn up by the Joint Committee.[1]

(*f*) The desirability of securing the support of examining bodies.

MONDAY, SEPTEMBER 4.

The following Report and Papers were read:—

1. *Report on the Mental and Physical Factors involved in Education.* See Reports, p. 177.

2. *Discussion on the Diagnosis of Feeble-mindedness.*

(i) *On the Nature and Definition of Mental Defect and its relation to the Normal. By* A. F. TREDGOLD, *L.R.C.P. Lond., M.R.C.S. Eng.*

Before we can satisfactorily discuss questions of diagnosis, training, and administrative care, it seems so essential that we should have clear ideas as to what mental defect really is, and what is its relation to the normal, that I propose to attempt to deal with this aspect of the matter.

The idiots are so palpably deficient in what we regard as the essential qualities of mind, that, from remote times, they have been set apart as an abnormal group of mankind. But closer knowledge has revealed the enormous variations in human mental capacity, and shown that just above the idiots there are the imbeciles, just above these the feeble-minded, above these again the dull and backward, then the ordinary average mass of mankind, next those of talent and marked ability, and finally, individuals of the highest order of intellect.

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[1] Report of the Joint Committee on Grammatical Terminology. London: John Murray, 1911. 6*d*.

Between none of these grades does there appear to be any hard-and-fast line of division. Whether we consider them from the standpoint of general intellectual capacity, from the result of a more detailed psychological analysis, or from the histological examination of the brain, it would seem as if the idiots could hardly be regarded as a peculiar and separate class, for the differences presented by those various groups of mankind seem to be in their essence not qualitative but merely quantitative ones.

This being the case, what is the mental 'normal,' and how are we to define what we mean by 'mental defect'? Where does the normal end and the abnormal begin? Indeed, in view of the fact that every living species naturally varies within very wide limits, are we justified in saying that there is any abnormal; may not even the idiots be but the expression at one end of the scale of normal mental variation, just as extreme brilliancy is its expression at the other end?

The fact that the differences are quantitative, however, does not negative the possibility of qualitative change, and there are reasons for thinking that a mere diminution of brain development may give rise to a mind of a very different order, to real differences in quality and nature.

In order to arrive at a basis of differentiation between the normal and abnormal we must go much deeper than ability to perform certain occupations; we must consider what are the essential qualities of mind.

I consider the essential faculty of mind to be the capacity for self-preservation. This results from the conscious adaptation of the individual to his environment, and any person deficient in this fundamental capacity must be regarded as abnormal and mentally deficient. I therefore define mental defect as *a condition due to arrested or imperfect development of the brain, in consequence of which the individual is incapable of maintaining an independent existence.*

Let us now apply this criterion to the various grades of mankind, and see where the line of division falls. With regard to the idiots, imbeciles, and feeble-minded, the mere statement of their accepted definitions suffices to show their incapacity for maintaining an independent existence, and consequently their abnormality.

With regard to the next group, the dull and backward, there is no authoritative definition, but a large experience of this class has convinced me that they are sharply differentiated from the feeble-minded in that they possess this capacity for self-preservation, and I would define them as—those persons who are below the average standard of intellectual ability, but are capable of managing themselves and their affairs with sufficient prudence to maintain an independent existence

Two other matters need a brief reference—*i.e.*, curability and diagnosis.

With regard to curability, it might be thought that, since the change is fundamentally a quantitative one, it should be possible, by special methods, to bring brain development up to the level of the normal standard. This is not confirmed by experience, and a consideration of the conditions to which mental defect is due shows the extreme unlikelihood of anything of the kind happening.

The question of diagnosis practically resolves itself into the differentiation of the feeble-minded from the dull and backward. The criterion which must be borne in mind is not ability to acquire book-learning, but to profit by experience, to adapt conduct to environment, and to maintain an independent existence. In my experience the careful examination of the mental and physical status of the child, with a consideration of his family and personal history, will usually enable the expert to make a diagnosis without much difficulty. A few cases occur where no definite opinion can be given until adolescence, but the occurrence of these, which are relatively few, should not prevent us adopting measures for the administrative cure of the majority, about whose condition there can be no doubt.

(ii) *Mental Tests for 'Backward' Children.*

By A. R. Abelson, *B.Sc., D.-ès-L.*

In late years increased attention has been given to the study of mental deficiency. There is a growing feeling that the methods at present in vogue for the recognition of mental defect are unsatisfactory. The diagnosis is often a very difficult one. Bright-looking children are to be found among the most

defective. Many are to all outward appearances so different from normal children. Some of the lowest-grade defectives possess remarkable cunning, which is often mistaken for intelligence.

It is important to determine what is the essential nature of mental deficiency.

The method of mental tests has been introduced for measuring mental ability, and also for ascertaining whether there is a central factor (*i.e.*, a general ability) common to all mental processes.

It is essential for us to assure ourselves that all the experimental results obtained furnish information of a reliable character about the abilities measured.[1]

My investigation, which lasted nearly three years, was carried out on those children who are usually spoken of as the 'backward' type. The tests were carried out under the best conditions possible. The children were examined singly, and disturbance of any kind was carefully avoided. They were encouraged as much as possible to do their best. In order to show evidence of the existence of a 'general ability' common to all mental processes, it was decided to measure as many abilities as could be conveniently arranged. The results of those tests then showed whether there was anything in common between the different processes.

The following tests were employed in this investigation :—

1 Tapping.
2 Crossing out rings.
3. Crossing out sets of dots.
4. Immediate memory for sentences.
5. Immediate memory for names.
6. Immediate memory for commissions.
7. Discrimination of length.
8. Interpretation of pictures.
9. Geometrical figures.

The head-teacher at each school was asked to draw up a list of the children to be examined in order of their 'practical intelligence.' She was also asked to give two further lists of the same children in order of their scholastic attainments —one for reading and the other for arithmetical ability. The results obtained from each of the tests gave a moderately high correlation with the teacher's estimate of 'practical intelligence,' but when all the tests were pooled together the correlation was quite high. On the other hand, neither reading nor arithmetical ability correlated very appreciably with the tests. This clearly shows that Binet is not altogether justified in considering scholastic attainment as the supreme criterion of 'general ability.' It also indicates that the earliest investigators were unwarranted in claiming that the tests are adequate for classifying children for scholastic purposes.

The investigation has shown that there is quite an appreciable intercorrelation between the tests, especially in the case of the girls. All evidence goes towards corroborating the popular conception that there is a central factor—a general ability—common to all mental processes.

By pooling together the results of all the tests we obtain the 'global' or 'amalgamated' result. By this means the specific factors in each of the tests are more or less eliminated, and the 'global' result should give us a very fair idea of the subject's 'general ability.'

There is every reason to believe that the central factor is not conative but rather intellectual in character. In the case of defectives it is not so much the willing process itself that is at fault as the ability to execute what is willed.

These defective children continue to develop appreciably up to quite a late age, whereas development in the case of normal children ceases to be marked at a much earlier stage in life.

The prevailing methods for examining mental deficiency are far too inadequate. The present custom of determining after a brief interview lasting two or three minutes the mental condition of a child can only excite grave misgivings.

In conclusion I would like to urge the necessity for the 'intermediate' school between the normal school and the school for mentally defectives. Some of the tests employed in this investigation could prove very useful for arranging the children for this purpose. There is no doubt that such an arrangement would render our educational system much more effective.

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[1] Dr. Spearman's method of Correlational Coefficients has been used by me throughout this investigation for measuring correlations and reliability.

(iii) *Eugenics and Education: The Problem of the Feeble-minded Child.*

By C. W. SALEEBY, *M.D.*, *F.R.S.E.*

Eugenics or good-breeding was the term applied by Galton, nearly thirty years ago, to his project of increasing the birth-rate amongst superior stocks. In recent years the idea has been widened, and we now speak of *positive eugenics*, the encouragement of parenthood on the part of the worthy, and *negative eugenics*, the discouragement of parenthood on the part of the unworthy, these terms having been introduced by myself some half-dozen years ago with Sir Francis' approval.

The primary contention of those whom I call Eugenists is abundantly supported by the feeble-minded child. The eugenist declares that education can educate only what heredity gives, that the feeble-minded child is strictly non-educable, and that the remedy proposed by negative eugenics alone meets the case. Lately the advocates of eugenics have been joined by recruits who employ eugenics as the latest catch-word against 'socialism,' and range themselves as anti-educationists, on the ground that genius and talent will always out, that education really effects nothing, 'nurture' being negligible compared with 'nature,' and that these efforts to save the 'unfit' disastrously handicap the 'fit.'

The object of this paper is to protest that grave disservice is done to eugenics by such partisans, and to repudiate them *in toto* so far as my eugenic demands are concerned. To this end I wish to show that the educator is indispensable in the eugenic interest, not least in the case of the feeble-minded child. We do our best for this child until the age of puberty, and then, when our care should be redoubled, the law deprives us of it. The law's delay in this matter is an outrage upon science and humanity. But when it is changed, what are we to do? The inexpert eugenist demands universal segregation. I suggest that the possible courses are various, that we must make the profoundest discrimination possible between one child and another, and that only the educator—with one psychological, and one medical eye—can perform this task.

The three possible courses are (1) the discharge of the child to become a member of the community and a possible parent; (2) the discharge of the child, after the performance of sterilisation, to become a member of the community, but not a possible parent; (3) the permanent care of the child: a decision always open, of course, to revision, as in the case of the insane. To adopt the third course in the case of children who are only backward or slow would be outrageous, as is the adoption of the first in the case of the typical feeble-minded child. The second possibility I merely note here for completeness' sake, and for consideration.

Now it is the educator alone, and he only through thorough and prolonged observation, who can distinguish between the various types of child. Deaf children, for instance, must be scrupulously classified, and here the work of Kerr Love and Macleod Yearsley must be remembered. The fundamental distinction between acquired and 'congenital' deafness must be made, for the former does not concern the eugenist at all, whilst the latter does. The public must be taught that the deaf child is not necessarily feeble-minded, any more than the deaf Beethoven was.

Again, it is constantly argued that the eugenist wants to lock up for life a dull or backward child who may merely be suffering from lack of sleep or suitable nutriment. But I, for one, wish nothing of the sort. I say to the educator: Yours must be the verdict. Daily for months or years the educator will observe such children, and treat them, until, at adolescence, their real nature will be known, and we can act accordingly.

I therefore ask educators to pursue their studies by the methods of Binet and the rest, so that, at the critical age of puberty, they may be able to advise society as to the course it must pursue with each child, having regard both to the present and to future generations.

3. *Discussion on the Education of Feeble-minded Children.*

(i) *Farm Colonies for the Feeble-minded. By* Miss Dendy, *M.A.*

Lifelong care for the feeble-minded is a necessity (1) because they are a serious menace to the State when at large, (2) because they are in great danger and are unable to protect themselves against the common risks of society. In providing such care there are three points to be considered (1) it must be such as will ensure efficient segregation of the sexes both from the outside world and in the institutions; (2) it must ensure the happiness and moral and physical welfare of the person cared for; (3) it must be as economical as is in any way possible.

Farm-colonies are the best means of securing that these three objects shall be attained. They should be arranged for the accommodation of both sexes; this makes for economy in management, as the men can produce garden-stuff for the women as well as for themselves, and the women can do the mending and making and washing for the men. They should be far enough from a town to make it difficult for relatives and friends to visit too often; they should, if possible, be near enough to some market to secure a ready sale for surplus produce. They should be the natural outcome of residential schools for feeble-minded boys and girls, to which schools they should be attached. The school life of the children should be ordered with a view to their ultimately becoming workers in the colony. Children should be admitted under the age of thirteen, so that they may be easily moulded to the life which it is desired they should live. There are great advantages in having the colony and school in connection; it is not desirable to break the chain of good habit which can be so easily formed during childhood. Residential schools will prove to be a great economy when the complete scheme for the care of the feeble-minded is undertaken by Government; when provision is made for older scholars in colony schools, it will not be so necessary to provide for them in day-schools; nor will it be necessary to provide for very young children in colony schools, if these are worked in conjunction with day-schools. Colonies cannot be made self-supporting; there will always be the cost of supervision to consider. Probably, in the best circumstances, this cost will prove to be the measure of the difference between self-support and dependence. Though the colonists cannot be self-supporting, they can do a great deal towards their own maintenance and be very happy in the doing of it. They will cost far less in farm colonies than in prisons and workhouses. It must be remembered that the feeble-minded are in any circumstances already a heavy charge upon the community; farm colonies would not impose a new burden; they would simply enable the burden to be borne more easily and at less expense, whilst at the same time checking the evil which makes them necessary. We care for the feeble-minded now, but we care for them partially and intermittently as criminals and paupers. The farm colony would supply complete and continuous care.

The object to be aimed at on a colony is that every one of the colonists shall do something; no idleness must be tolerated anywhere. Idleness is fatal for the health and morals of the feeble-minded. Even imbeciles can learn to do effective work under proper supervision. It is necessary to provide for the complete separation of the sexes after they leave the school-room; it is well for the little ones to have their lessons together, but they should have separate play-grounds.

It is desirable that any colony should begin in a small way; it is much easier to start a scheme on the right lines when a few children only have to be handled at first. Sandlebridge colony began with fifteen small boys and the same number of girls. There are 230 boys and girls and young men and women in residence, of all ages from six years to twenty-three. Seventy are over the age of sixteen. The first house was opened in 1901. It was found that it was possible so to educate the children as to make a tradition of good manners and good behaviour generally. Children taken in since have been to a great extent educated and trained by contact with these scholars, who were broken in at the beginning of our work.

It is far more important that boys and girls should learn to be decent, clean, and industrious than that they should painfully acquire a little inefficient book-knowledge.

(Waverley and Sandlebridge were described.)

(ii) *The Education of the Feeble-minded.* *By* Miss E. M. Burgwin.

The London School Board commenced the work of educating the feeble-minded in the year 1892, and the work has gone steadily on under the London County Council. The order of reference stated that 'Schools for the Special Instruction of Children' should be established who, by reason of mental defects, could not be properly taught in ordinary classes or by ordinary school methods. The methods adopted depend largely upon the type of child attending the school. All must, however, start training by the 'objective' method. They must see the object, feel it, and talk about it before its name or quality can be understood by them. The classification presents many difficulties, *e.g.*, some have bad speech defects, others acute hearing and good articulation. Others, again, and this a large proportion, are very clumsy, having little power of using the fingers properly—so that the ordinary senses have to be carefully developed, and the teacher has to be constantly on the watch to detect and correct faults.

It is a great advantage in the education of these pupils that they are individually instructed, and at the same time by being in a class of twenty pupils they receive the stimulus of working with others of similar if varied capacity. The power of concentration is possibly the hardest to obtain, but experience proves that little is accomplished until this in some measure is secured. Lessons must be not longer than thirty minutes each, the subjects must be put before the pupils in an attractive manner, much repetition, though varied, is necessary. The verbal lesson on an 'ear of corn' is illustrated by blackboard drawings—the children subsequently draw, paint, or model the ear, and so learn its colour and form, and to what use the grain is put, and finally a loaf of bread is put before the class. Thus many lessons have to be given before the knowledge is of much use to the pupils.

Activity is the essence of all the teaching. The feeble-minded must be ever at work or play. For the junior schools containing boys and girls between the ages of seven and twelve, half-time is given to the ordinary subjects of reading, writing, numbers, &c., and half-time to varied occupations. Whilst some can never be taught a letter of the alphabet, and others cannot calculate, there are few who cannot be taught to work with their hands with some degree of efficiency.

It is false teaching to specialise too early—*i.e.*, no boy should be trained as a shoemaker only until he is fourteen years of age and has had a fair chance of showing what his own inclinations are. Success in work is only secured by the hearty co-operation of the worker, for though thorough training may develop what is in the child, no teaching can draw out what is not within. From the junior schools the boys of twelve are drafted into the senior boys' schools, where three-quarters of the school hours are given to advanced manual occupations, such as woodwork, shoemaking, tailoring, &c., and a school for elder girls has been opened where advanced practical housewifery, including cookery, laundry, making of garments, &c., are taught. This having proved a success, others are to be shortly opened. Physical exercises are taught every day to correct the slovenly, uncertain movements so characteristic of this class of pupil. Lessons, work, and recreation have to be under the ever constant supervision of the teachers. The teachers of the London Special Schools are all trained and well qualified for their arduous work. All the pupils are admitted to the schools on the order of the medical officer. This is often a difficult matter to decide, for the border line between the normal and the subnormal is often very fine. There are pupils who, if questioned about their life in the streets, answer intelligently, and yet their whole conduct is so thoroughly bad that it is clear their criminal instincts are the result of their feeble-mindedness. This has been frequently proven by cases which have passed through the schools. There is great and urgent need for further legislation with regard to pupils who, in spite of the teaching and training given in the schools, clearly prove by their actions that they are not fit to be at liberty, and yet having had the teaching would, under supervision, work profitably under the Colony system.

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4. *Backward Children.* *By* Professor J. A. Green, *M.A.*

The backward child differs from the mentally defective in the fact that he is educable, but his education must often be a specialised one. He is at present

the dregs of our schools; he passes through them but never reaches further than a middle standard. Inquiry shows that there are from 2 to 3 per cent. of children in the elementary schools who are two years behind the average of the class they are working in. This is a mass of useful human material which deserves study. The city of Mannheim has made a most interesting attempt to grapple with this problem.

TUESDAY, SEPTEMBER 5.

1. *Discussion on Practical Education in Dockyard and Naval Schools.*

(i) *The Royal Dockyard Schools. By* T. DAWE.

These schools, which were founded by the Admiralty in 1843, have played an important part in the development of naval architecture in this country. Nearly all our leading naval constructors of the past half-century commenced their careers as dockyard apprentices, attended classes in the dockyard schools for four or five years; and, for the exceptional ability shown by them in those classes, were selected for a higher course of professional training. Among these may be mentioned the late Sir E. J. Reid, Sir N. Barnaby, Sir W. H. White, and Sir Philip Watts, successive Directors of Naval Construction.

Boys enter the dockyards as apprentices between the ages of fourteen and sixteen years by means of an open competitive Civil Service examination, the subjects of which are English, mathematics, elementary science, and drawing. They are allowed to attend school for two afternoons and three evenings per week, the remainder of their time being devoted to the practical acquisition of their trades. The full school course extends over a period of four years, but there is a 'weeding-out' process at the end of each year, so that only the best of the apprentices take the full course. A few (from one to four) of the best of these are selected by examination from all the yards for a further three years' course of advanced instruction at the Royal Naval College, Greenwich, after which they become (if qualified) members of the Royal Corps of Naval Constructors.

These higher appointments can, however, only fall to a few, but the others are eligible for the considerable number of minor but important posts at the Admiralty and in the dockyards—such as those of foremen, inspectors of trades, and draughtsmen—for which a trained intelligence and a well-stored mind are of very great value. Most of these posts are filled by men who have had the advantage of a dockyard school training.

The subjects taught are: practical mathematics (including plane trigonometry, co-ordinate geometry of two and three dimensions, the calculus and easy differential equations); theoretical and applied mechanics (including graphical statics, strength of materials, balancing of engines, mechanism and elementary hydraulics); elementary chemistry; heat and steam; metallurgy; magnetism and electricity; and mechanical drawing. English history and composition are taken during the first two years. Every apprentice works in the school laboratory for about two hours per week. Lectures on naval architecture, marine engineering, and electrical engineering are given to apprentices during their third and fourth years; and fourth year apprentices who attend school are given special facilities in the yard for acquiring a practical knowledge of the drawing appertaining to their own trades.

(ii) *Schools for Boy Artificers. By* W. H. T. PAIN.

2. *The Present Position of German in Secondary Schools. By* G. F. BRIDGE.

In the Report of the Board of Education for 1906–07 it was stated that 'German, in Wales, as in England, is finding a difficulty in maintaining its ground.' The reports on Scotland for 1907 and England for 1908 contained

similar statements. The statistics of the public examinations for which schools enter their pupils bear out these statements. The reports of the Oxford and Cambridge Schools Examination Board showed a steady diminution in the percentage of candidates taking German, as the following figures show:—

Higher Certificate.

	No. of Candidates	No. taking German	Percentage
1896	2,121	323	15·25
1909	2,621	257	9·8

Lower Certificate.

1896	891	193	21·6
1909	1,347	241	18

These figures give some idea of the number of boys and girls in schools where the leaving age is eighteen who attain a fair standard in German.

The figures for the Oxford and Cambridge Local Examinations, which are utilised mainly by the great town day-schools and schools where the leaving age is sixteen or seventeen, are as follows:—

Oxford Senior Local Examination.

	No. of Candidates	No. taking German	Percentage
1895	1,414	351	24·2
1907	6,370	360	5·6

Cambridge Senior Local Examination.

1895	1,952	506	25·1
1906	3,736	324	8·6

The great increase in the number of entries since 1895 is due largely to the institution in England, since the Act of 1902, of a number of municipal and county schools in which only one foreign language can be taught, and also to the fact that these examinations are now largely used by elementary teachers as qualifying examinations; but these considerations do not give a wholly satisfactory explanation, least of all of the considerable diminution of candidates taking German in the Cambridge Examination.

Whether or not the amount of German done in schools is actually diminishing, there is much evidence that only a quite insignificant proportion of scholars in secondary schools attain a satisfactory standard in the language. In July 1910 there entered from the eleven provincial towns in England with more than 200,000 inhabitants 1,701 candidates for the Oxford Senior Local Examination. Of these 742 obtained certificates in French, and only 38 in German. That is to say, only one candidate in forty-five gave evidence of an adequate knowledge of German. If the figures for the Cambridge Local and other examinations were added, the proportion would probably not be altered. The figures for Matriculation point in the same direction. At the Joint Matriculation Examination of the Northern Universities in 1907, about nine per cent. of the candidates offered German. The proportion at London is about the same.

The evidence for a low standard of attainment in German therefore seems pretty clear. The main reasons for this probably are the late stage at which German is begun and the under-estimating of its difficulty. French is almost invariably the first language begun in schools; German is usually learnt for only two or three years. For the successful teaching of a language, either a few hours for several years or a considerable number of hours for a few years are required. German gets neither. In the schools of the West Riding German is taught only in the upper classes and gets only three hours a week. The difficulty of German is under-estimated, because well-educated people who have had a linguistic training find it tolerably easy to learn to read it. But the acquirement of a command of it for speech and writing by boys and girls is quite another thing.

It is sound doctrine that only one foreign language should be begun at a time, and there is no reason for wishing to oust French from its position in the

general body of schools. But it is desirable that there should be a large number of schools in which German is the staple language. Of these at present there are very few.

It is also very desirable that there should be a number of schools, like the German *Realschulen*, in which English and modern languages would be made the backbone of humanistic studies, and Latin taught only as a special subject to those who needed it.

The Board of Education shows no sympathy with German. A joint memorandum calling attention to the state of German in schools was sent to the President in 1908 by the British Science Guild, the London Chamber of Commerce, the Teachers' Guild, the Society of German University Teachers, and the Modern Language Association, but the reply amounted practically to this—that nothing could be done.

It remains for public opinion to require that German should be effectively taught to a much larger number of children than study it at present.

3. *School-books and Eyesight.* By G. F. Daniell, *B.Sc.*

Short sight is rarely, if ever, congenital, and is usually an artificial condition induced by the misuse of eyes during the period of growth. Short sight (1) is rare before the age of six; (2) increases in amount and degree in the higher classes or standards of schools, and is the only disease of which the incidence is higher among the older than among the younger scholars; (3) increases with the number of hours employed in literary work; (4) is worse in badly-lighted than in well-lighted schools.

Recognising that short sight is mainly the result of faulty education, several authorities have laid down rules to be observed in the production of books to be used by children under twelve years of age. Thus I find the following: School books should have sufficient thickness of paper, and large, thick-faced, well-defined type. Letters and lines well spaced, and good margins to the pages. Ink black and paper white or tinted yellow. Unbleached paper of a tawny-grey tint has been recommended. Glazed paper is strongly condemned. The lines of the school-book should not exceed 4 inches, or 10 cm., in length. No type should be allowed which necessitates holding the book at a less distance than twelve inches. Types recommended are 'double-pica' for very young children; 'pica leaded' for children of age six to eleven, and 'small pica leaded' for the older children. Small type annotations are undesirable. Not more than two lines of type should be included within a vertical distance of 1 cm. (The height of small pica letters is 1.75 mm., and of pica is 2.0 mm.). I have recently tested various books exhibited by publishers at educational conferences, and have found that the above rules are not consistently observed. The matter is of sufficient importance to call for action by education authorities, either central or local. Now that the organisation of educational administration has proceeded so far, and especially in view of the responsibilities undertaken by education authorities as regards medical inspection, it appears desirable that Section L should investigate the question of the relation of school-books to eyesight. It should not be forgotten that the short-sighted lose much unconscious education. It is hoped that a British Association report may formulate a standard to which all school-books should conform; at least, all books intended for use by children under twelve. Education authorities might exclude from their requisition-lists (after an appointed date, of which notice would be given to publishers) all books which did not satisfy the standard requirements. Thereby much preventable injury to eyesight would be prevented.

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4. *Suggested Reforms in the Teaching of Science.* By P. Shaw Jeffery.

EVENING DISCOURSES.

FRIDAY, SEPTEMBER 1.

The Physiology of Submarine Work. *By* LEONARD HILL, *M.B., F.R.S.*

COMPRESSED air is used in all the great subaqueous works of to-day, in tunnelling, harbour works, shaft sinking in wet soil, pier and bridge building, diving for pearl and sponges, salvage work, &c. The intercommunication of the great cities of the world depends on tunnels built with the aid of compressed air. All such works are limited to a certain depth by the pathological effects produced on the workers.

The Naked Diver.

The naked diver preceded the diver who uses compressed air. The body of the naked diver is pressed upon by the water, equally and in all its parts, by a pressure equal to one atmosphere (15 lb. per square inch) for every 33 feet (10·3 m.) of depth. He takes a deep breath or two, fills his lungs before, and holds his breath during the dive. He places a foot in a stirrup attached to a heavy stone, and so is carried rapidly to the bottom. The air in his lungs, air passages, and middle ear must be compressed to half its volume at 33 feet (2 atmospheres absolute), to one-third at 66 feet (3 atmospheres absolute), to a quarter at 99 feet (4 atmospheres absolute). The depths attained are usually not greater than 60 to 70 feet. The compression of the air in the lungs is rendered possible by the upward movement of the diaphragm and sinking in of the abdomen. Some of the air in the lungs must dissolve in the blood according to the law of partial pressures.

The amount of nitrogen dissolved from air at 1 atmosphere pressure and at body temperature is 0·85 per cent. This is the figure for the watery part of the body. The fat dissolves about 5 per cent., an important fact discovered by Vernon. At 66 feet (3 atmospheres) the watery part can hold 0·85 × 3 and the fat 5 × 3 per cent. Putting the fat against the solids of the body (bones, &c.), which do not dissolve gas, it may be assumed that the whole body dissolves about 1 per cent. of nitrogen per atmosphere. A man weighing 60 kgm., then, will dissolve when compressed from 1 to 3 atmospheres about 1,200 c.c. of nitrogen, that is, if time were allowed for the blood to convey the nitrogen from the lungs to the tissues till saturation occurred. In the lungs there are about 4,000 c.c. of air. Of course, far less than 1,200 c.c. will be dissolved in the minute the diver is submerged. In addition to the solution of nitrogen, the blood will take up more oxygen, both in solution and chemically combined with the hæmoglobin; the diver working hard gathering pearl or sponge will use oxygen rapidly. It is clear, then, that the absolute volume of air must be reduced during the minute the diver stays submerged, but it is difficult to estimate by how much. To allow for the reduction of volume, both by compression and solution, in the body, it is clear that the diver must fill his lungs well, otherwise the diaphragm will be pushed up to such an extent that the action of his heart and the circulation of the blood become impeded. It is this, in part, which sets a limit to the depth to which the naked diver can go. The bleedings, from mouth and nose, which the unpractised naked diver suffers, are due, no doubt, to both the congestion of the blood which results from holding the breath and to rarefaction of the air in the nose and middle ear during the ascent. Some time ago I put this question to Sir E. Ray Lankester: What happens in the case of the whale which sounds, perhaps, to a depth of 1,000 feet? Does the whale allow the lungs to fill with water as the air becomes compressed to one-thirtieth of its volume; if not, what is the mechanism engaged which permits such compression? I fancy the whale allows water to enter, and blows this out again when it ascends to the surface. The naked diver can extend his stay under water by deep breathing before the plunge and filling the lungs with

oxygen. The breathing is regulated by the concentration of acid (or the hydrogen ion) in the blood—carbonic acid is the natural end-product of muscular metabolism; lactic acid is produced in the muscles when there is a deficiency of oxygen. Deep breathing before the dive will wash out much of the carbonic acid in the blood, owing to the increased ventilation of the lungs. The blood and muscles, too, will be better oxygenated, and thus less lactic acid will be produced during the submergence. If oxygen is breathed this will be still more the case, as Martin Flack and I have shown. After deep breathing air for 2 minutes we easily held our breath 2 or 3 minutes. After deep breathing oxygen 5 minutes one of our subjects held his breath over 8 minutes and another just over 9 minutes. Taking a deep breath and then holding it, J. M. pulled up a 60 lb. weight seventeen times in 23 seconds before he was compelled to take another breath. After deep breathing air for 2 minutes he held his breath while he pulled it up thirty times in 50 seconds; and after deep breathing oxygen for 2 minutes, seventy times in 85 seconds. Similarly after a deep breath, R. A. R. held it while he ran 113 yards in 29 seconds; 150 yards in $35\frac{3}{5}$ seconds after deep breathing air for 2 minutes; 256 yards in $62\frac{1}{5}$ seconds after deep breathing oxygen for 2 minutes. S. E. ran on one breath 470 yards in 110 seconds after deep breathing oxygen! At the end he ran blindly, having lost consciousness owing to the high concentration of CO_2 in his blood.

The high pressure of oxygen in the lungs enables one to hold one's breath until the pressure of CO_2 reaches 10 to 11 per cent., while if the pressure of oxygen is low a breath must be taken when that of the CO_2 reaches no more than half this amount. A balance is struck between the relative pressures of oxygen and carbonic acid.

It is clear, then, that the naked diver can stay longer and do more efficient work if he deeply breathed and filled his lungs with oxygen before each dive.

I will demonstrate my little apparatus by means of which oxygen can be generated from oxylithe (peroxide of sodium) and inhaled. Two blocks of oxylithe are put in the metal box—the generator—and a pint of water in the rubber bag. The mouthpiece of the bag is clipped and the water allowed to enter the generator. Oxygen fills the bag, and a solution of caustic soda is formed. The man breathes in and out of the bag. This invention allows oxygen to be carried about, and has proved useful for mountain climbers who at high altitudes suffer from oxygen want.

Diving birds have double the normal volume of blood (Bohr), just as the llama and the human inhabitant of high altitudes have more red corpuscles and hæmoglobin. Observations on the blood of naked divers would probably show the same increase.

The Mechanical Effects of Pressure on the Body.

The body of the naked diver, at a depth of say 66 feet, is pressed upon equally on all sides by the water, and by a pressure of 3 atmospheres; for 33 feet of water = 1 atmosphere. The gas in his lungs (and intestines) is compressed into one-third of its volume, and that is the only effect of the pressure, for the pressure is transmitted equally and instantly by the fluids of the body to all parts, and as the fluids are practically incompressible the pressure has no mechanical effect.

The diver who uses gear, or the caisson worker, is surrounded with compressed air and breathes freely in it. The body of either is pressed upon by the air, and the air pressure must always be just greater than that of the water to keep the latter out of the dress, bell, or caisson. I will demonstrate this on the model diver, diving bell, and caisson. Whether it be air or water that *uniformly* presses upon the body, the tissue fluids transmit the pressure equally; and thus, although it is computed that an extra atmosphere means an additional total pressure of 15,000 to 20,000 kilograms (40,000 lb.) on the body of a man, no mechanical effect is produced. Living matter is a jelly containing about 80 per cent. of water, and, like water, is practically incompressible. Since attention was first drawn to compressed-air illness the larger number of medical writers, ignorant of physical laws, have supposed that exposure to compressed air mechanically alters the distribution of the blood, forcing it inwards and causing a congestion, which is suddenly and dangerously altered on decompression.

I have noted that the same false views are even now put forward in the daily press to explain the symptoms, due to the rarefaction of the air, endured by aeroplanists. The sickness of high altitudes suffered by mountain climbers, balloonists, and aeroplanists has nothing to do with the mere mechanical effect of the lowering of barometric pressure. In an atmosphere enriched with oxygen U. Mosse has endured a lowering of barometric pressure until he could span the height of the column of mercury in the barometer with his hand. Oxygen want, due to the rarefaction of the air, is the prime cause of altitude sickness. At an altitude of 18,000 feet, where the barometric pressure is halved, a man, filling his lungs with air, takes in only half the *weight* of oxygen which he takes in at sea-level. His respiratory and circulatory organs can scarcely work hard enough for the body to get enough oxygen.

That mere mechanical pressure, uniformly applied, is of no importance to living matter is shown by the existence of life in the greatest depths yet sounded, where the superincumbent pressure may equal two, three, and even five miles of water. By means of a small chamber and hydraulic pump and lantern I project the shadow of the frog's heart beating in a suitable salt solution at a pressure of 2,000 lb. (133 atmospheres), equivalent to a depth of nearly a mile of water. Regnard has compressed living aquatic animals, frogs' muscles, &c., to 500 and even 1,000 atmospheres, and has found at the highest pressures the tissues become stiff and take up water, and life is destroyed. His experimental results and those of the deep-sea soundings (*Challenger* Reports) are in contradiction. Regnard's experiments require repetition, with careful attention to the chemical composition of the water in which the living matter is compressed.

I refute the mechanical theories of compressed-air illness by this experiment: A frog's web is stretched over the glass window of the small pressure chamber, and is illuminated by the arc light, so that the circulation of the blood is projected on the screen. The circulation remains unchanged when the pressure is rapidly raised to 20 or even 50 atmospheres.

Manometric records of blood pressure taken from mammals enclosed in a pressure chamber, or from man, show no noteworthy change when the pressure is raised to 3 atmospheres. Similarly I can show that a frog's heart or muscle contracts normally when suddenly submitted to a pressure of air equal to 50 atmospheres. After a time the contraction languishes, but that is not due to the pressure *per se*, but to poisoning by the high pressure (concentration) of oxygen. The pressure uniformly applied has no mechanical effect on the living protoplasm.

The Evolution of Diving Apparatus.

The use of compressed air for submarine work was a matter of slow development, owing, not to lack of invention, but to want of efficient air-pumps and flexible tubes. The naked divers had a barrel, or bell-shaped vessel, standing on a tripod, lowered down to them full of air, to which they could return and breathe the air within every minute or two. They also chewed pieces of sponge dipped in oil, probably because swallowing inhibits the respiratory centre and checks the desire to breathe. One of the oldest inventions is that of a pipe conveying air from the surface to the mouth of the diver. Such a device cannot be used at any depth, because the body is pressed upon by the water *plus* the atmospheric pressure, while the lungs are exposed to the atmospheric pressure alone. This makes breathing difficult and dangerously congests the lungs with blood, as I can demonstrate by this model. The cupping glass also demonstrates the congestive effect produced by lessening the atmospheric pressure at one part of the body only. Bernouilli (seventeenth century) formulated the correct theory that the diver must be supplied with air at the pressure of the water surrounding him. In the older inventions the air escaped from under the helmet and only the head was dry. The air pressure in the modern diving-dress (invented by Siebe), regulated by a valve in the helmet, keeps the water from entering at the wrist cuff, and the whole body is kept dry and warm and equally compressed. I demonstrate the modern diving dress which Messrs. Siebe, Gorman & Co. have lent me for this lecture. The pressure produced by the pump must keep up to that of the water as the diver descends, so long as he does not fall down. He can descend rapidly, *e.g.*, 100 feet in two minutes, but

it is dangerous to fall down, for if the pump does not keep up with the water pressure a cupping effect is produced, and the diver may suffer hæmorrhage from the lungs and mouth and nose.

By means of the escape valve the diver can adjust his specific gravity so that he is only slightly heavier than water, and can move easily along the bottom. He fills his dress more or less with air, just as the fish fills its swim bladder. If the dress becomes over-filled the diver is 'blown up' to the surface, and in the old style of dress he may become helpless, arms and legs blown out stiff, unable to open his valve. To prevent this accident the legs of the latest fashionable dress are laced up, as I show you, in this style.

The Diving Bell and Caisson.

Anyone who pushed an inverted glass under water and saw it did not fill, would conceive the idea of a diving bell. Sinclair (1665) fashioned a simple wooden bell to recover treasure from an Armada ship off Mull. At 33½ feet the air in such a bell is compressed to half its volume, and this, together with lack of ventilation, rendered such a bell of little use.

Halley, the astronomer, used a pipe and bellows for shallow work, while for deep work, when his bellows failed, he sank a cask full of air to a deeper level than the bell. From the cask to the bell passed a tube, and the water entering the cask through a hole displaced the air into the bell (model demonstrated). He descended to nine to ten fathoms with four others, and used up seven to eight barrels of air.

With the building of efficient air-pumps, Smeaton (1778) applied the bell to the important use of building the piles of bridges. Triger (1839) applied it to the sinking of coal shafts through quicksands, and the bell became thus evolved into the modern caisson—a steel chamber provided with a cutting edge below and an air-lock above for allowing the men to enter and leave without raising the bell. Finally the caisson was applied to the purpose of horizontally tunnelling under rivers. To effect this a steel shield provided with cutting edge is driven forward by hydraulic jacks. Screens are placed in the shield to allow excavation of the soil in front of it. As fast as the shield is driven forward, segments of the iron tunnel are built into place. Water is kept out of the work by the use of compressed air. On entering, the men are 'compressed' in the air-lock, *i.e.*, the air-pressure is raised to that in the tunnel, and on leaving the tunnel they are 'decompressed,' *i.e.*, the air-pressure is lowered in the lock down to the normal, so that the outer door of the lock may be opened.

A diver is 'compressed' on descending into the water, as the pressure of his air-pump always keeps up to that of the water. On coming up he is 'decompressed.'

The Ventilation of the Diving Dress.

Divers in deep-sea water have in the past been unable to stay down long owing to a feeling of oppression, which they have ascribed to the pressure of the water. Mr. Greenwood and I have exposed ourselves in our compressed-air chamber to +92 lb. (7 atmospheres) and +75 lb. (6 atmospheres) respectively, and found our breathing just as free and easy as at atmospheric pressure. Beyond the increasing nasal twang of the voice there are no symptoms produced, and there is no sense by which the pressure can be estimated. John Haldane has done great service in proving that the cause of the oppression is due to increased partial pressure of CO_2 in the helmet owing to deficient ventilation. The breathing is regulated by the pressure of CO_2 in the lungs, so that this is kept at 5 to 6 per cent. of an atmosphere. During work the amount of CO_2 given off is trebled or quadrupled, and during hard work it may be increased six-fold. The ventilation of the lung is increased *pari passu* so as to keep the percentage of CO_2 in the lung normal.

If the pressure of CO_2 in the inspired air is increased, the breathing is deepened so as to keep normal the CO_2 percentage in the lung. If the inspired air contain 3 per cent. CO_2, the volume breathed is about doubled, and moderate work in such air causes as much panting as hard work in pure air.

When the atmospheric pressure is altered, it is not the percentage but the absolute pressure of CO_2 which controls the breathing. Thus the percentage found in Greenwood's lungs was 5·4 at 1 atmosphere, 2·7 at 2 atmospheres, 0·9 at 6 atmospheres, and the partial pressure of CO_2—*i.e.*, the percentage multiplied

by the pressure in atmospheres—in each case was 5·4 per cent. of an atmosphere. This holds good also down to about two-thirds of an atmosphere in analyses taken at high altitudes. At lower atmospheric pressures than this oxygen want comes in, with the production of lactic acid in the tissues and blood, as a disturbing factor. It is clear, then, that the effect of a given percentage of CO_2 in the diver's helmet varies with the depth. If air containing 5 per cent. CO_2 produces great panting at 1 atmosphere, air containing $\frac{5}{7 \cdot 4} = 0 \cdot 68$ per cent. will produce the same degree of panting at 35 fathoms (7·4 atmospheres). It follows from this that whatever the pressure a diver is under, he requires the same volume of air measured at that pressure to ensure the ventilation of his helmet. At 2 atmospheres the ventilation must be doubled, at 3 atmospheres trebled, at 6 atmospheres increased six-fold. Under the old conditions of working, often with leaky pumps and tired men to pump, the ventilation has been acutally less, not six times greater as it ought to be, at a depth of 165 feet.

With a pressure of 2 per cent. of CO_2 in the inspired air the pulmonary ventilation is increased about 50 per cent.; with 3 per cent. about 100 per cent.; with 4 per cent. about 200 per cent; with 5 per cent. about 300 per cent.; and with 6 per cent. about 500 per cent. If the diver is working hard the extra production of CO_2 will make him pant, and this coupled with the effect of the excess in the helmet, which often reaches 3 to 4 per cent., makes breathing distressing and the feeling of oppression intense. Thus at a depth of 139 feet with a CO_2 pressure of 4·28 per cent. of an atmosphere, Lieutenant Damant was unable to continue for more than 8 minutes the exertion of lifting a weight of 56 lb. about 9 feet per minute. The Admiralty Committee found that the divers could continue work for long periods at depths of even 210 feet so long as the CO_2 pressure was kept below 3 per cent. of an atmosphere.

To keep the CO_2 down to this level a diver ought to have at least 1·5 cubic feet of air per minute when working, and he must have this volume of air pass through the helmet at whatever pressure he be at. Each cylinder of the regulation service pump ought to yield $\frac{1}{10}$ cubic feet per revolution. Assuming an unavoidable leakage of the pumps of 10 per cent. at 100 feet and 24 per cent. at 200 feet, the Admiralty Committee ordered for 33 feet (depth) one cylinder, thirty revolutions per minute, and two men per spell, the work being estimated at 4,440 foot-lb. per minute; while for 165 feet depth four cylinders, twenty-seven revolutions, and twelve men are required—the work being 34,000 foot-lb. per minute; for 198 feet (depth) six cylinders, twenty-three revolutions, eighteen men, the work being 43,000 foot-lb. per minute. Provision ought to be made to give a third more than this supply if the diver gets into difficulties.

At 210 feet thirty-six men were working very hard in alternate 5-minute spells of rest and work, and were scarcely able to keep up the proper air supply. Long handles were supplied to allow three men on each side of the pump.

To avoid this excessive labour, R. H. Davis (of Siebe, Gorman & Co.) and I have added to the diving dress this metal box containing trays of caustic soda. A mouthpiece is placed within the helmet, and a tube leads from this through the soda-box and back to the helmet. The diver when oppressed in the slightest degree can take hold of the mouthpiece with his lips, and breathe through the caustic soda, and so lessen the concentration of CO_2. There is no risk of his suffering from want of oxygen so long as the pumps give him a moderate supply of air. This device ought to save a great deal of hard pumping work.

The Self-contained Diving Dress.

We have also contrived a self-contained diving dress fitted with cylinders containing compressed air enriched with oxygen (to 50 per cent.), and a caustic-soda chamber. The oxygen supply is delivered to the helmet by a reducing valve in constant supply (5 litres per minute), and the force of the oxygen stream is used, by means of an injector, to suck the air in the helmet through the caustic-soda chamber. No life-line or air-pipe is carried, only a light telephone cable, and this makes the dress suitable for exploration of flooded mines, tunnels, ships, &c., through which the heavy pipes and lines cannot be dragged. Air containing 50 per cent. oxygen is used in place of oxygen (Haldane), so that there is no risk of oxygen poisoning if used for an hour at depths of 70 to 80 feet, or even 100 feet, for half an hour.

Compressed-air Illness.

In all the great compressed-air works from first to last the men have suffered from illness and loss of life. There is no risk going into or staying in the caisson, as Pol and Watelle (1854) said, 'On ne paie qu'en sortant.' Out of 64 workers observed by them, 47 remained well, 14 had slight illnesses, 16 more or less severe, 2 died. An absolute pressure of 4¼ atmospheres was reached. The men worked two shifts per diem of 4 hours each, and were decompressed in 30 minutes. At the St. Louis Bridge works, out of 352 workers there were 119 cases, 56 of paralysis, and 14 deaths. The absolute pressure reached 4½ atmospheres.

At the Nussdorf works 320 cases among 675 workers and 2 deaths, the absolute pressure reached was 3½ atmospheres.

In the East River tunnels (New York), under well-regulated conditions, the percentage of illness was 0·66, of death 0·0035 in 557,000 man-shifts, with a decompression rate of 15 minutes from an absolute pressure of 3 atmospheres. Of the 320 cases at Nussdorf, Von Schrotter observed 68 cases of ear trouble, 105 of pain in the muscles, 60 of pains in the joints, 10 of girdle pains, 17 of partial paralysis, 26 of paralysis of the lower half of the body, 14 of vertigo and noises in the ear, 2 of sudden deafness, 1 of loss of speech, 13 of asphyxial phenomena. Out of 3,692 cases at the East River tunnels observed by Keays 88·78 per cent. were pains in joints and muscles, 'bends,' 1·26 per cent. pains and prostration, 2·16 per cent. nervous symptoms, 5·33 per cent. vertigo, 1·62 per cent. dyspnœa and oppression, chokes, 0·46 per cent. loss of consciousness and collapse. There were 20 deaths. The trouble in the ear, which occurs during compression, is due to the inequality of air-pressure on either side of the drum of the ear. It is relieved at once by opening the Eustachian tubes by swallowing, or by a forced expiration with the nose and mouth held shut. None of the other manifold symptoms comes on while the men are under pressure. Mules were kept for a year in the Hudson Tunnel at 3 atmospheres absolute, and were healthy enough to kick and bite at all comers (E. W. Moir). The illness comes on after decompression, usually within a few minutes to half-an-hour, sometimes even later.

The Cause of the Illness.

The cause of the illness—so striking in its protean nature—was made clear by Paul Bert (1879), who showed by experiments on animals (1) that nitrogen gas is dissolved by the blood and tissue fluids in proportion to the pressure of the air (Dalton's law); (2) that the dissolved gas bubbles off and effervesces in the blood when an animal or man is decompressed too rapidly—the bubbles by blocking up the capillaries, and cutting off the blood supply here or there, produce the symptoms; (3) that during exposure to 8 or 9 atmospheres there is no ill-effect until the partial pressure of oxygen dissolved in the blood reaches such a point that it acts as a tissue poison; (4) that the illness, which occurs on decompression, is prevented by making the period of decompression sufficiently slow, by allowing time for the dissolved nitrogen to escape from the lungs. Looking through the works of Robert Boyle, I found that, after the invention of his air-pump, he 'had a mind to observe whether when the air from time to time was drawn away, there would not appear some hidden swelling, greater or less, of the body of the animal by the spring and expansion of some air (or aerial matter) included in the thorax or the abdomen.' He recorded that a viper's body and neck grew prodigiously tumid; that a bubble of air appeared in the aqueous humour of a viper's eye; that the heart of an eel grew very tumid and sent forth little bubbles; that blood boiled 'over the pot' until the blood occupied only one-quarter of the volume of the whole, so great was the expansion of the bubbles given off from it. In the following surmise, concerning the death of animals submitted to rarefaction, Boyle forestalls Bert. 'Another suspicion we should have entertained concerning the death of animals—namely, that upon the sudden removal of the wonted pressure of the ambient air, the warm blood of those animals was brought to an effervescence or ebullition; or at least so vehemently expanded, as to disturb the circulation of the blood, and so disorder the whole economy of the body.'

Hoppe-Seyler (1857) demonstrated bubbles in the blood-vessels of animals submitted to rarefaction. This was denied by Bert, but confirmed in the case of a rabbit by Greenwood and myself.

Out of thirty autopsies done on fatal cases of caisson illness, in nineteen gas-bubbles were visible in the blood-vessels; of the other cases most were old-standing lesions of the spinal cord.

The paralysis so often produced is due to a local death and degeneration of the spinal cord, produced by bubbles blocking the circulation there (Von Schrötter, Heller, and Mager).

Proofs that nitrogen gas dissolved in the body fluids and fat is the cause of the illness are the following. The blood collected from the artery of an animal while under pressure, and analysed with the gas-pump, shows that the amount of dissolved nitrogen varies with the pressure. Roughly, 1 per cent. per atmosphere is dissolved (Bert, Hill, and Macleod).

Exposed to 1 atmosphere at body temperature, blood dissolves just about 1 per cent. N, to 2 atmospheres 2 per cent., to 3 atmospheres 3 per cent., and so on. The tissue fluids take up the dissolved gas from the blood, and with time the whole body becomes saturated, according to Dalton's law. The saturation of the body fluids takes time, since the blood forms but 5 per cent. of the whole body weight, and it is the blood alone that comes in direct contact in the lungs with the increased atmospheric pressure. Probably about 5 kilograms of blood circulate through the lungs per minute, and this blood conveys the absorbed nitrogen to the 60 kilograms of tissues. The arterial blood saturated in the lungs yields the nitrogen to the tissues, and returns to be saturated again in the lungs. Those tissues which are plentifully supplied with blood will become saturated rapidly, while less vascular areas, and parts in a state of vasco-constriction, will saturate very slowly.

C. Ham and I exposed rats to 10 to 20 atmospheres, killed them by instant decompression, and then, opening their bodies under water, collected and analysed the gas set free therein. We obtained in this gas CO_2 6·7 to 16 per cent., O_2 2·1 to 8·7 per cent., N 80 to 87 per cent., and a volume of N greater than that calculated according to solubility of N in tissue fluid. Some of the excess we found was due to air swallowed while under pressure, the rest to solution of N in fat.

M. Greenwood and I have tested upon ourselves the rate of saturation, using the urine as a test fluid. We were compressed in a large boiler, placed at our disposal by Messrs. Siebe, Gorman & Co. The chamber was fitted with electric light and telephone, and taps for slow decompression. The pressure was raised by means of a diving-pump driven by a gas engine. We drank a quart of water before entering, and collected samples of urine at varying pressures and times. The urine, collected in sealed bulbs, was evacuated by the blood gas pump. We found the urine secreted in the next ten minutes after reaching any given pressure is saturated with N at that pressure.

To demonstrate the bubbling off of nitrogen on rapid decompression, I have spread the web of a frog's foot or wing of a bat over the glass window of a pressure chamber. The circulation of the blood is projected on a screen by aid of microscope and arc light. We can thus observe the circulation under 20 atmospheres of air, and watch the bubbles forming in the capillaries on rapid decompression. Recompression diminishes the size and finally drives the bubbles again into solution.

When the larger mammals are exposed to high pressure, such as 8 atmospheres, for an hour or so, and are then rapidly decompressed, they usually die in a few minutes. Small mammals, such as mice and rats, may escape, owing to the small bulk of body and rapid respiration and circulation. The young of rabbits, cats, &c., also escape more frequently than old animals. This is due rather to their smaller weight and more rapid circulation than to the youth of the body tissues. Paralysis in the limbs follows too rapid decompression, or the animals fall over and become unconscious. Noise of gas bubbles gurgling in the heart may be heard. Respiration becomes embarrassed, and the animals die. On dissection, the peritoneal cavity may be found distended with gas, or the stomach, and gas may be seen in the intestine. A part of this gas arises from the fermentative processes of digestion, and from air swallowed during compression. The veins of the portal system, the venæ cavæ, are seen to contain chains of bubbles; the heart is full of froth. Small hæmorrhages may be present in the lungs. The edges of the lobes of the lung are emphysematous, blown out by the rapid decompression. The fat often is full of small bubbles, so too are the con-

nective tissues. Bubbles are seen in the joints, and may appear in the aqueous humour of the eye. On opening the skull, bubbles are seen in the veins of the brain. The bubbles are not restricted to the veins, but may also be seen in the arteries. The coronary vessels of the heart often show chains of bubbles. On microscopic examination, the bubbles are seen in the capillaries; here and there they run together and form larger bubbles, sometimes rupturing the walls of the vessel, and compressing the surrounding tissues. In the larger animals decompressed from 100 lb. in 4 to 7 seconds, we have found the cells of the liver, kidney, &c., vacuolated or even burst by bubbles. The gas set free in the heart can be collected and analysed; about 80 per cent. of it is found to be nitrogen (Bert, Von Schrotter, Hill, and Macleod). Catsaras lowered dogs in a diving dress to depths of 43·7 m., and after about an hour rapidly drew them to the surface. He found bubbles set free in these dogs just as in those exposed in a pressure chamber.

In animals which escape without any severe symptoms, some gas bubbles may be found in the veins even six hours later. This shows how long it may take for nitrogen gas once set free as bubbles to escape from the lungs, and explains why caisson workers may suddenly be seized some half-hour or more after leaving the works. In such cases the bubbles may be swept from the abdominal veins—where they do no harm—into the heart, and impede the action of this organ, or they may penetrate the pulmonary circulation and enter the arterial system, and block up, perchance, the coronary arteries, or others in the brain or spinal cord.

The blood is a colloidal solution, and it takes time for the nitrogen to come out of solution and for the small bubbles to run together to form visible bubbles. The gas bubbles tend to collect in the veins, as the blood travels quickly through the arteries and slowly in the veins. It is only when the gas in the veins becomes sufficient in amount to produce foam in the heart, or when gas bubbles block up arteries of vital import, that grave symptoms arise. The place where bubbles in the arteries must always produce serious results is the central nervous system. In the liver, kidneys, muscles, fat, &c., bubbles may embolise small arteries and produce no grave effect, but in the spinal cord the interruption of the blood supply to any group of cells or tract of fibres is evidenced at once by pain and anæsthesia, spasm, and paralysis. In the medulla oblongata arrest of the circulation will stop respiration, and bubbles lodging there may produce immediate death. Lodging in the arteries of the great brain, bubbles may produce hemiplegia, aphasia, blindness, or mental disturbance.

Among men some are affected and others not. We can look for an explanation in the varying state of the blood, in fatness, in the varying vigour of the circulation and respiration and the effect of fatigue, in vaso-motor changes which alter the relative volume of circulating blood in viscera and muscles, and in the fermentative processes going on in the alimentary tract. The young man who is in perfect health, with powerful heart and deep respiration, can expel the dissolved nitrogen from his lungs far more rapidly than the old, the fat, the intemperate, or one who is over-fatigued by excessive labour. The records of caisson works seem to show that most men under twenty escape, while the percentage of cases increases with age, and is highest for men over forty; that long shifts increase the number of cases; that men who work the air-locks, passing material through, and undergoing frequent and short-lasting compression and decompression, are not affected. The longer the shift the more complete the saturation of the body; the higher the pressure the greater the risks and the graver the symptoms. The records show that practically no cases occur with a pressure below 2 to 2½ atmospheres absolute, even though the decompression period be made only a minute or two.

At the Rotherhithe tunnel the decompression period was three minutes, and the maximal pressure + 22 lb. No cases of any gravity occurred. Nevertheless, we proved that the workers had excess of nitrogen in their bodies after decompression. We gave them a quart of beer to drink in the tunnel 30 minutes before decompression to provoke diuresis, and made them empty their bladders just before, and again 10 minutes after, decompression. Their urine yielded more than the normal volume of N. The urine passed immediately after their decompression obviously effervesced.

Influence of Fatness.

As the fat holds five or six times as much nitrogen in solution as the blood, it saturates and desaturates slowly.

J. F. Twort and I have found 35·55 per cent. of nitrogen dissolved in olive oil which had been exposed to 7½ atmospheres. The risk of exposure to compressed air varies with the fatness of the animal (Boycott and Damant). Greenwood and I have found fat pigs weighing 100 to 120 lb. are more susceptible than smaller pigs 50 to 60 lb. The bubbles once set free in the subcutaneous fat of pigs may stay there for days after decompression, as we have found to our cost, for it has seriously damaged the sale of the animals to the butcher, since the fat does not bleed white, but remains pink and mottled. All the results prove that fat men should be excluded from compressed air work at pressures over 2 atmospheres absolute.

The varying percentage of fat in the blood, chyle, and liver must be an important factor in the evolution of bubbles in the blood. The less fat in the food eaten by caisson workers the better.

Ventilation and Illness.

Much has been made of the impurity of the air as a contributory cause of caisson sickness, in particular, of the percentage of CO_2. The ventilation of the tunnels built by the London County Council under the Thames have been carried out at enormous and needless expense, in order to keep the CO_2 percentage down to a very low level. The work of the English physiologists is against this view. Divers generally work with 1, 2, or even 3 per cent. of an atmosphere CO_2 in their helmets. We have exposed ourselves to 3 to 4 per cent. of an atmosphere CO_2 without untoward results, beyond increased frequency of respiration—which prevents any increased concentration of CO_2 in the body.

Recently I have carried out many experiments on students sealed up in a small air-tight chamber, and found, as Haldane has, that it is the heat, moisture, and stillness of the air which cause discomfort and fatigue, and not the excess of CO_2, or deficiency of oxygen in the air breathed. The putting on of powerful electric fans by whirling the air and cooling the body gives very great relief, even when there is 4 to 5 per cent. of CO_2 in the chamber.

In open-air treatment the coolness and movement of the air are the essential qualities which promote health by stimulating the activity, the metabolism, and nervous well-being of the body.

Hot, moist, still air causes fatigue by taxing the cooling mechanism of the body; blood is sent to the skin to be cooled which ought to be going to muscle and brain. Fatigue increases the danger of decompression by making the circulation and respiration less efficient. The heat causes more blood to come to the skin and a more complete saturation with nitrogen there. The cold in the decompression chamber—due to expansion of the air—causes vaso-constriction and repels the blood from the skin and so stops its desaturation. We have lost pigs by taking them from the warm caisson into the cold air.

Over-hot and moist—that is, under-ventilated—caissons have, therefore, a higher morbidity. To secure efficient work the wet-bulb temperature must be kept below 75° F. (Haldane). The men should not pass from a warm caisson to a cold air-lock and a cold outside world. They should go through a warm lock to a warm room.

Hot moist atmospheres are very disadvantageous to health and work. If the wet-bulb temperature is high in the caisson, the current of air should be increased or electric fans used to cool the workers. Electric fans have enormously increased the efficiency and health of Europeans in the tropics. An excess of CO_2 in the air-lock, or diver's helmet, during decompression is favourable, as it increases the pulmonary ventilation and the outbreaking of nitrogen. Haldane advises the air-pump to be slackened purposely. There is no harm in breathing 1 or even 2 per cent. of CO_2.

Methods of Decompression.

The safety of compressed-air workers depends on the relation of the period of decompression to that of compression.

The period of the saturation or desaturation of the body with nitrogen depends on the relation between the circulating volume of the blood and the

volume (1) of the tissue fluid, (2) of the body fat which dissolves the nitrogen—remember the fat dissolves 5 or 6 times as much as the tissue fluid. The more often the whole volume of the blood circulates round the body the quicker will be the saturation or desaturation. The smaller the body the more often does the volume of blood course round it. A mouse's heart beat six hundred or seven hundred times a minute against a man's seventy (F. Buchanan). The circulation and rate of respiratory exchange are twenty times faster in the mouse. In the case of a man, the smaller man, the leaner and harder the man (less fat and tissue fluid), the quicker will saturate and desaturate. The rate of the circulation and percentage of fat vary in different organs. There are parts quickly and parts slowly saturated or desaturated. The joints, tendons, subcutaneous fat, abdominal fat depots, are relatively slow parts. The white matter of the brain and spinal cord has much fat in it, while the grey matter has little fat and a more active circulation. In the white matter of the spinal cord bubbles commonly form and lead to a stoppage of the circulation there, death of the tissue, and paralysis. Bubbles in the subcutaneous fat, or fat depots of the belly may be compared to stones scattered in the fields, and bubbles in the spinal cord to rocks thrown down on the main railway lines of London.

Muscular work increases the circulation and pulmonary ventilation five or six even ten times, if the work is very hard. In warm, moist caissons the cutaneous vessels are dilated and the circulation accelerated, and this makes the saturation of the peripheral parts quicker than in the case of the diver, who is surrounded with cool water. The diver also does not work so hard and so long as the caisson-worker. Therefore the caisson-worker suffers far more from 'bends.' The diver goes to much greater pressures for short times, and after a quick decompression may suffer from asphyxia, symptoms of paralysis—arising from bubbles in the heart and pulmonary vessels, or in the spinal cord. The caisson-worker when decompressed stands quiet, and is subjected to the cooling effect of the expanding air, and this constricts his cutaneous vessels and prevents desaturation of the peripheral parts. The caisson-worker ought to be decompressed in an air-lock which is comfortably warmed, and he ought to exercise himself hard in order to keep up the circulation and pulmonary ventilation, and so hasten desaturation.

Haldane thinks that the body of man is about half-saturated in one hour, and about saturated in 4 hours. Bornstein says 6 or 7 hours are required for saturation of the fat. Greenwood and I found that the urine, secreted by the kidney, is about saturated after 10 minutes exposure to 4 atmosphere. About 20 minutes were occupied in reaching this pressure. On decompression of a saturated animal the viscosity of the colloidal blood prevents the formation of bubbles under a certain difference of gas pressure. It is found by experience that it is safe to decompress men in a minute or two from 2 atmospheres to 1. Since the volume of a gas is halved at 2 atmospheres made $\frac{1}{4}$ at 4 atmospheres, $\frac{1}{8}$ at 8 atmospheres, and the volume of a bubble is doubled on lowering the pressure from 8 to 4, 6 to 3, 4 to 2, or 2 to 1, Haldane concluded it was safe to come rapidly from 4 to 2, 6 to 3, or 8 to 4 atmospheres. The supersaturated tissues then give nitrogen to the blood, and the blood to the lungs, and the nitrogen escapes without bubbling at the half-pressure stage, where a long pause is given. Successive stages may be given when required to secure the desaturation of the body, each stage by producing a safe degree of supersaturation accelerating the outgiving of the dissolved nitrogen. The stage method of decompression initiated by Haldane, and adopted by the Admiralty, has an advantage over the uniform in that it prevents the further and perhaps dangerous saturation of the slow parts. Supposing a diver had been for half an hour at 6 atmospheres pressure, if he were decompressed on the old plan, slowly and uniformly, his fat would become further saturated up to 5 atmospheres, while he was being decompressed from 6 to 5 atmospheres. On the other hand, if he is decompressed rapidly from 6 to 3, the further saturation of the fat at pressures above 3 atmospheres is altogether prevented. The stage method is of value to divers, who go down for short periods, and do not work very hard, as it prevents the saturation of slow parts and hastens the period of decompression.

Caisson-workers who do 4 to 8 hours' shifts are practically saturated, but they, too, are best decompressed by the stage method because it accelerates the outgiving of the nitrogen by producing a safe degree of supersaturation of the blood. The safety is greatly enhanced if hard muscular work is done during the

pauses. This can be effected by having a series of air-locks, and making the men walk, or better, climb between each. In the East River tunnels this method was tried with good results—(1) +40 to +29 lb. in 5 minutes; (2) 10 minutes walking in +29 lb.; (3) +29 to +12½ lb. in 8 minutes; (4) 10 minutes walking in +12½ lb.; (5) +12½ to +0 in 15 minutes. Lengths of tunnel were arranged between locks for walking in. Total time, 48 minutes. The Admiralty table enforces 97 minutes for this pressure.

As there were 1·60 per cent. cases of 'bends' and no serious ones- the Admiralty time is demonstrated to be unnecessarily long. This is particularly so if *hard work* is done during decompression, for the same amount of nitrogen would be expelled in about one fifth of the time as during rest.

Greenwood and I have tested the stage method on pigs which are more like men in shape, diet, and habit than goats—the animals used in the investigations conducted for the Admiralty Committee. It appears from our results fairly safe to decompress even fat pigs from 6 atmospheres to 2⅓ atmospheres in about ten minutes, and then after a pause of 1½ hour from 2⅓ to 1 atmosphere in twenty minutes. The pigs slept quietly in the warm caisson, and never moved, and being fat, were very unfavourable subjects. One death and no severe case of illness occurred among 47 pigs weighing 50 to 100 lb.; one severe and three slight cases among 19 goats weighing 39 to 57 lb. A similar decompression of fat pigs from 7 atmospheres, allowing 105 to 120 minutes interval at 2⅓ atmospheres, gave unfavourable results, seven deaths and one severe case—among 27 pigs weighing 81 to 115 lb. Only one pig out of all showed any symptoms after reaching the stage at 2⅓ atmospheres At these very high pressures there is great risk unless time enough is given, and plenty of exercise taken during the pause.

For pressures up to 4 atmospheres the method employed by Mr. Yapp at the East River Tunnel is evidently a very good one. For pressure 2 to 3 atmospheres it is an advantage to do work immediately after decompression, supposing work cannot be provided between two air-locks (Bornstein). At the Greenwich tunnel, now being built, the men climb the shaft 60 feet high after decompression, and since I made the suggestion, and the engineer, Mr. E. H. Tabor, carried it out, the number of cases of 'bends' has dropped from 1 in 94 to 1 in 240 man-shifts. For higher pressures it would not be safe to take exercise after, it ought to be taken during decompression and the pauses between the stage decompressions. The importance of this cannot be insisted on too much. Exercise during decompression is the simplest means of rendering compressed-air work safe, and of keeping the period of decompression of a reasonable length.

The question of the length of shift desirable has been much discussed. Long shifts of 8 hours are found to give more illness than shifts of, say, 1 to 2 hours. Every practical caisson engineer agrees to that. Divers are decompressed in a few minutes from high pressures (5 to 6 atmospheres), with comparative immunity, if they have been down for only a few minutes. Cases of illness occur when they exceed their stay, or after a succession of dives, each of which helps to saturate slow parts and increases the fatigue of the diver. The Admiralty table fixes the period spent at the bottom so as to prevent saturation of 'slow' parts and shorten the period of decompression. The descent is hastened for the same reason. It is quite safe to descend to 200 feet in 2 minutes; slow descents only increase risk by increasing the saturation of the body. In the matter of the caisson-workers, at the East River Tunnel, two 3-hour shifts per diem, with 3 hours' rest between, gave 1·07 per cent. cases, and one 8-hour shift 0·62 per cent. cases. The men are so far saturated in 3 hours of hard work, that doubling the decompressions is worse than extending the shift to 8 hours. As bubbles may persist for a long time in the tissues, and may act as starting-points for the formation of other bubbles, it is wise to give long intervals of time between shifts—also in a short interval slow parts may not become desaturated. Haldane has suggested the men should return to a 'purgatory' chamber—say, at 2 atmospheres, and eat their dinner and rest there in the mid-period of an 8-hour shift and again at the end of the shift when, while waiting for decompression to 1 atmosphere, they could wash, change their clothes, and have some hot coffee to stimulate the circulation. In any large tunnel-works such a chamber could be easily constructed out of a section of the tunnel. This would suffice for stage decompression, and would give excellent results if the men could be persuaded to take exercise in it, or be given oxygen to breathe before decompression to 1 atmosphere.

The quickest method of desaturating the body is to 'wash' the nitrogen out by breathing oxygen for a few minutes before and during decompression The only question is the safety of this proceeding, for high concentrations of oxygen acts as a poison.

Oxygen Poisoning.

(1) All kinds of animals, worms, snails, flies, spiders, frogs, &c., are instantly convulsed and killed by exposure to 50 atmospheres oxygen; (2) The frog's heart beats, nerve conducts and muscle contracts for some time in 50 atmospheres oxygen, but there is evidence of progressive diminution in functional power, the muscles behave like a fatigued muscle; (3) Mice exposed to 10 atmospheres oxygen are thrown into tetanic spasms, and on being decompressed continue to be convulsed by a touch. Bubbles of oxygen are to be then found in the central nervous system compressing the nerve cells. As the bubbles are oxygen the cells do not die and the animals may recover, the oxygen being absorbed by the tissues and the circulation re established; (4) + 3 atmospheres oxygen convulsed animals in 30 to 60 minutes (Bert and Lorrain Smith), and the poisonous effect, depending as it does on the partial pressure of oxygen in the blood, comes on just as soon in larger animals as in small, *e g.*, cats, rats, and mice; (5) Fatal inflammation of the lung is produced by exposure to high partial pressures of oxygen, *e.g.*, after 25 hours' continuous exposure to +7 atmospheres of air = 170 per cent. atmosphere oxygen (Lorrain Smith). This can be prevented by using nitrogen to dilute the air, and so lowering the partial pressure of oxygen; (6) It is quite safe to breathe 1 atmosphere oxygen, or 5 atmospheres air, for 3 to 4 hours. The men who wear the Fleuss apparatus for rescue work in mines have breathed it day after day for this period. I have spent much time with Mr. R. H. Davis in perfecting this apparatus on physiological lines, and so have studied particularly the effect of oxygen on man. In very hard work there may be a deficiency of the oxygen supply in the body, and then breathing oxygen helps the working power of the man.

If the body is getting enough oxygen the breathing of it has no effect on the metabolism. The man at rest cannot be fanned into a greater rate of activity by breathing oxygen. Poisonous pressures of oxygen lower the metabolism and diminish the carbonic acid output of animals. Martin Flack and I showed that the breathing of oxygen just before a race may help an athlete, because during his great effort he uses up oxygen quicker than his respiration and circulation can provide it. A shortage of oxygen leads to the production of acid products in the tissues and blood, which causes breathlessness and stiffness of the muscles.

Lactic acid appears in the urine after a short period of hard running (Ruffel). Feldman and I have found that breathing oxygen by means of the Fleuss dress during the run prevents the excretion or lessens the amount of lactic acid excreted. Thus the pressure of oxygen helps the caisson worker to do his work more easily. During decompression it is of no advantage to him to have the pressure of oxygen lowered.

Bornstein at the Elbe Tunnel works has breathed oxygen (90 to 95 per cent) for forty-eight minutes at a pressure of 3 atmospheres Two other engineers breathed it for thirty minutes. Bornstein freed himself from 'bends' by this means. These periods are the outside limits of safety. Bornstein began to have slight convulsive movements.

For every atmosphere the body dissolves nitrogen to about 1 per cent. of its mass, for a 70 kgm. man, say, 1.000 c.c. per atmosphere. Von Schrötter calculates that oxygen *plus* exercise would turn out 1,000 c.c. in five minutes, probably more.

Oxygen can be breathed economically by means of the Fleuss apparatus which was used so effectively in the last great colliery disaster at Bolton. The apparatus can be put on and oxygen breathed for ten minutes before and during decompression. The breathing-bag must be washed out several times with a current of oxygen, from the emergency valve provided, to accelerate the output of nitrogen.

J. F. Twort and I have investigated the effect of breathing oxygen on the volume of nitrogen dissolved in the urine. Precautions were taken to collect the urine without contact with the atmosphere. About three pints of water

were drunk thirty minutes before collection of urine, so that samples could be obtained every seven minutes or so. The samples were pumped out by means of the Gardner and Buckmaster gas-pump, in which there are no taps and leakage of air is practically nil.

I cite the results of two experiments:—

I. Breathed air at 3 atmospheres. After 15 minutes emptied bladder. Sample I., collected 7 minutes later at 3 atmospheres. Decompressed to 1⅔ atmosphere in 3 minutes. Sample II., collected 6 minutes later at 1⅔ atmosphere. Decompressed to 1 atmosphere in 3 minutes. Sample III., collected 3 minutes later at 1 atmosphere.

	Nitrogen	Oxygen	Pressure atm.	Nitrogen calculated (0·85 per atm.)
Sample I. . . .	3·054	0·152	3	2·55
Sample II. . . .	2·859	0·144	⅔	1·416
Sample III. . . .	1·609	0·081	1	0·85

II. At 3 atmospheres for 44 minutes. Emptied bladder and breathed oxygen for 9 minutes, then took Sample I. Decompressed to 1⅔ atmosphere in 2 minutes. Took Sample II. 4 minutes later. Decompressed to 1 atmosphere in 1½ minute. Took Sample III. 5 minutes later.

	Nitrogen	Oxygen	Pressure atm.	Nitrogen calculated
Sample I. . . .	2·091	0·297	3	2·55
Sample II. . . .	0·8835	0·1985	1⅔	1·416
Sample III. . . .	0·5751	0·0941	1	0·85

The results show that the urine is supersaturated with nitrogen after decompression in the first case, and undersaturated after breathing oxygen in the second case.

The ideal method, then, for safe decompression from high pressure is (1) oxygen breathing for five minutes and rapid decompression to 2 atmospheres, (2) pause during which oxygen is breathed and exercise taken, (3) rapid decompression to 1 atmosphere while oxygen breathing and exercise are continued.

The period of decompression can be notably shortened by such means, how far further experiment will show. We want to know in particular how the fat of the spinal cord is desaturated under these conditions. The 'quick' parts are evidently put right in a few minutes. Further experiments on fat pigs should give the required information.

Recompression.

Recompression is the one method of cure for the illness. Pol and Watelle (1854) recorded the benefit of this. Men with 'bends' went back under pressure. A. Smith suggested the use of a recompression chamber at Brooklyn. E. W. Moir instituted it at the Hudson Tunnel. All caisson works are now provided with such. Men at the East River Tunnel works have truly been raised from the dead by its means.

In the frog's web experiment I have observed the bubbles shrink up on recompression. Experiments on animals show that recompression must be applied at once in dangerous cases, before vital parts are killed by the interference with the circulation. 'Bends' may be relieved by compression long after they have come on.

Recompression relieved 90 per cent. of the cases at the East River Tunnel, and all but 0·5 per cent. were partly relieved by its means. Oxygen breathing can be employed with advantage in the medical lock. Decompression from the lock must be slow, for some of the bubbles having run together to form larger ones only shrink up on recompression, and do not quickly go into solution. These expand again on decompression. J. F. Twort and I have observed this happening, and measured the bubbles under the microscope.

For deep-diving work a recompression chamber should always be at hand. I have contrived a double-chambered diving-bell, one chamber open to the sea, the other closed save for a manhole communicating with the first. The divers after completing their work enter the inner chamber and close the manhole. The bell is raised on deck, and the men decompressed by the stage method.

Such a contrivance prevents exposure to cold during, or risk of storm preventing, gradual decompression in the ordinary way by the diver climbing the shotted rope.

In the carrying out of these researches, and in the demonstrations given this evening, I am greatly indebted to Messrs. Siebe, Gorman & Co. for their help

MONDAY, SEPTEMBER 4.

Links with the Past in the Plant World.

By Professor A. C. Seward, *F.R.S.*

The primary object of this discourse was to call attention to the existence in the floras of different parts of the world of survivals from the past; incidentally, other topics were referred to which were suggested by a consideration of the records of the rocks.

1. *The British Flora.*—There are many problems connected with the origin and manner of introduction of British flowering plants, which afford scope for speculation and research. The occurrence of Mediterranean plants in Ireland and in the south-west of England is a case in point. Are such genera as Arbutus and Dabœcia survivals from the Tertiary period, or have they been introduced by natural agency since the Glacial period?

2. *Ferns.*—Recent ferns supply interesting examples of species with a wide geographical distribution, and of species or genera confined to a small area. The study of fossil ferns enables us to demonstrate in certain cases the great antiquity of some of those genera which are now characterised by a very restricted geographical range. The Osmundaceæ, the genera Matonia, Dipteris, and Gleichenia are selected as illustrations of the bearing of palæobotanical data on the history of existing ferns.

3. *Conifers.*—The relative antiquity and past distribution of the Conifers are questions beset with numerous difficulties, but we have satisfactory evidence in regard to the former abundance and wide distribution of such genera as Sequoia and Araucaria. The mammoth trees and redwoods of California and the two members of the Araucaria family, Araucaria and Agathis, represent survivals from the past which were formerly abundant in many parts of the northern hemisphere where they have long ceased to exist.

4. *The Maidenhair-tree.*—One of the most striking examples of a link with the past is afforded by the Maidenhair-tree of the Far East, *Ginkgo biloba* (L.). This tree is no longer known in an absolutely wild state; it is frequently found in China and Japan in the groves of temples, and is now common in cultivation in Europe and America. Ginkgo and allied genera are recorded from Mesozoic and Tertiary strata in nearly all parts of the world, and fossils usually assigned to the Ginkgoales are not uncommon in Palæozoic rocks.

5. *Geographical Distribution, &c.*—Researches into the floras of the past, more particularly those of the Mesozoic period, have thrown considerable light on changes which have taken place in the geographical distribution of certain families and genera of seed-bearing plants.

The Jurassic floras of the world exhibit a remarkable uniformity in their general composition as contrasted with the diversity of existing floras. The study of the plant-geography of former ages is well worthy of attention, not only from the point of view of the relative antiquity of plants but in connection with the capabilities of plants as colonisers. The late appearance of the flowering plants, the dominant group in the plant-kingdom, is a fact of great importance in relation to comparisons between the plant-geography of the Jurassic era and the present distribution of vegetation.

Questions connected with the study of plants as 'thermometers of the ages,' though presenting many difficulties, are of considerable interest and importance, and deserve closer investigation than they have hitherto received.

APPENDIX I.

CATALOGUE OF DESTRUCTIVE EARTHQUAKES.

By J. MILNE, *D.Sc., F.R.S.*

INTRODUCTION.

The following small Catalogue, which has taken several years to compile, is issued under the auspices of the Seismological Committee of the British Association. It represents excerpts from manuscripts and publications received from most countries in the world.

In 1858, at the end of a Report to the British Association, Robert Mallet says: "We have thus extracted all the information that our catalogue, or indeed any further cataloguing of earthquakes seems capable of giving us." Farther on he remarks, "In conclusion, I would repeat my conviction that a further expenditure of labour in earthquake catalogues of the character hitherto compiled, and alone possible from the data to have been compiled, is now a waste of scientific time and labour." To appreciate the opinion which is here so strongly expressed it is necessary to examine the catalogues to which reference is made. Although in several respects they exhibit differences, they have also strong resemblances. From the earliest historical times to the 17th century, the entries are comparatively few in number as compared with entries made subsequently. As Mallet puts it, the expanding character of catalogues has followed the progress of human knowledge, discovery, and diffusion of mankind. The records before the Christian era, and prior to the year 1700, are practically confined to occurrences in Southern Europe, China and Japan. It may, however, be noted that when Mallet wrote, records relating to the two last-mentioned countries (to which we may add India) were but few in number. In early times the entries for all countries refer for the most part to widespread disasters. References to small disturbances were never chronicled, or if they were, they have been lost. Only that which was large survived. As the material civilisation of Europe spread, new countries were settled, printing became common, and records of natural phenomena became more numerous. They however changed in character. Small events found a place in history, with the result that in the compilations referring to the last 300 years, we find megaseisms and microseisms side by side. The characteristics of catalogues to which Mr. Mallet refers are therefore as follow: First, the entries for early times, although

comparatively few in number, are fairly homogeneous in their character. Secondly, the entries for recent times are comparatively numerous but they are extremely heterogeneous. References to cataclysms are lost amid long lists of mere earth tremors. Efforts which have resulted in the creation or extension of faults and the devastation of districts stand side by side with references to "aftershocks" or slight adjustments in the settlement of strata which may not have rattled a window or awakened a sleeper.

Although much time has been expended on the analyses of these catalogues it is not surprising to find that the outcome has been more suggestive than definitive, and but little has been learned.

The present Catalogue is an attempt to give a list of earthquakes which have announced changes of geological importance in the earth's crust; movements which have probably resulted in the creation or extension of a line of fault, the vibrations accompanying which could, with proper instruments, have been recorded over a continent or the whole surface of our world. Small earthquakes have been excluded, while the number of large earthquakes both for ancient and modern times has been extended. As an illustration of exclusion, I may mention that between 1800 and 1808, which are years taken at random, I find in Mallet's catalogue 407 entries. Only 37 of these, which were accompanied by structural damage, have been retained. Other catalogues such as those of Perrey and Fuchs have been treated similarly.

The large catalogue of Count F. Montessus de Ballore, stored in the library of the Geographical Society in Paris, occupies 26 metres of bookshelves and contains about 140,000 entries. In the light of recent researches (see Geographical Journal, Jan. 1910) which indicate that 30,000 earthquakes may occur annually, the number of entries in the catalogue of Montessus cannot be regarded as abnormal. If the seismicity of the world has been constant during the last 1900 years, the number of earthquakes which have taken place during this period may have been 60,000,000. If we exclude small disturbances, and only consider world-shaking earthquakes, which at the present time take place at the rate of about 60 per year, these would during the same interval have numbered some 100,000. The entries in the present Catalogue are less than 6,000. Several reasons for the smallness of this number compared with what we should expect to find in a complete list, have already been indicated. To these it must be added that it has only been possible within the last few years to record disturbances originating in oceanic beds and in uninhabited regions. It is these instrumental records made during the last 10 years which have enabled me to give estimates of the total number of large earthquakes occurring in the world per annum. A list of earthquakes, each of which has been recorded over a

hemisphere or the whole world since 1898, will shortly be published as a supplement to this Catalogue.

In addition to this, I may add that during the last half century, archives previously unknown or inaccessible have become available. The *Jishin Nendaiki*, or Earthquake Calendars of Japan and Chinese histories have been translated, whilst almost every civilised country has found one or more specialists to work out its seismic history.

Foundation of Catalogue.—As a foundation for the present list I first made excerpts from the catalogues of Mallet, Perrey and Fuchs. This was extended from lists culled from catalogues and histories of many foreign countries, a work which involved translation from Chinese, Japanese, Russian, Icelandic and other languages. In this I received great assistance from Mr. E. H. Parker, Professor of Chinese at the University of Manchester, my assistant, Mr. Shinobu Hirota, Mr. W. A. Taylor, Mr. C. A. Gosch, Monsieur E. Scavenius, the Rev. M. S. Masó, S.J., Mr. H. Hope-Jones, Count Montessus de Ballore and other gentlemen to all of whom I now offer my sincere thanks. The back numbers of *The Times*, *Nature*, and other papers gave a certain amount of information. Lastly, I have had the advantage of a large number of lists and documents relating to earthquakes collected from various parts of the world and put at my disposal by the Foreign, Colonial and India Offices. To all these sources of information I will refer in detail. In sifting this somewhat large quantity of material, it might be suggested that the process of elimination may occasionally have been too strict. For example, small earthquakes may have been rejected which were really the surface record of shocks which were megaseismic at their origin. Inasmuch as the rejections are confined to what are clearly *aftershocks*, and to disturbances which were only *felt* at one or two places and that experience has shown that vibrations which can be felt have not travelled very far, I do not think the errors due to omission are numerous. Not only have certain small earthquakes been omitted, but whenever the information on which the accounts of large ones has been based have been of a doubtful character, these also have been rejected. For example, Mallet refers to disturbances which Barrata, the Italian seismologist, either omits or considers to be founded upon information which is unreliable. Mr. W. A. Taylor points out that the earthquakes of 843 and 846 in Naples, 950 in Syracuse, 981-995 in Sicily, 1007 or 1008 in Apulia, and 1245 in Nardo, are disturbances of a doubtful character, and are spoken of as mendacious. I have also omitted earthquakes which are said to have accompanied the birth and death of sacred personages and martyrs. At the birth and death of Christ, at the martyrdom of St. Agatha, at Calabria in A.D. 255, the day of burial of St. Agnes, A.D. 304 and at the decapitation of Sts. Valantino and Ilaria in A.D. 306 we are told great earthquakes are said to have taken place.

That great earthquakes took place in years approximating to certain of these dates there is no doubt, but we must remember that to fix a date in those early times is extremely difficult.

The Catalogue attempts to give the year, month and occasionally the hour when a large earthquake occurred; the country or district shaken; the names of the places most disturbed, the intensity of the movement and the authority from which information has been derived.

Dates.—The entries in this Catalogue embrace the period A.D. 7, November 10th, to A.D. 1899, December 31st. For recent times it is easy to give a date but for ancient times and in particular countries it is often difficult.

Not only has confusion arisen owing to differences in chronologies, but also owing to changes in *style* and as the early workers were probably without tables enabling them to transpose the dates of one system into that of another, mistakes have been made. It is therefore not surprising that we meet with two or more dates for the same event. In this Catalogue, in the majority of cases, the dates adopted are those found in the catalogues mentioned, but when translating new material as for example that from China and Japan, European dates have been computed. For these latter it is seldom that the hour has been mentioned. Where it is given as that of *the horse*, *the cow*, *the monkey*, or by some other animal name, this has been omitted, its reliability being doubtful. In the few cases where hours are noted they are expressed in Greenwich mean Civil Time, in which 24 hours corresponds to midnight and 12 to midday.

The dates given for China, Japan and Korea have been computed from tables published by the late William Bramsen, and lately republished in the Transactions of the Asiatic Society of Japan by the Rev. E. W. Clement who adds comparative chronological tables of the Christian Era, Japanese Eras and Emperors, Chinese Eras and Emperors and Korean Kings, with years of the Sexagenary Cycles from 660 B.C. to 1910 A.D.

Although a particular day is usually specified as the one on which an earthquake took place, it must be remembered that these may have been "foreshocks" and "aftershocks" in previous and subsequent dates.

Names of Countries and Places.—The names of Countries, Provinces, Departments, &c., together with political boundaries have during historical times had many changes. So far as possible the names used are those given by the authorities quoted, and correspond to names found in an English atlas. Provinces, Departments, Counties, States and Districts are given in parentheses. For example (Florence), (Campobasso), (Cosenza) indicate Provinces, while Florence, Campobasso, Cosenza indicate towns. Places which suffered most are printed in italics. In certain instances Districts, Towns or Islands, like Savoy, Nice and Malta, may appear to have the wrong country prefix. Savoy and Nice are now attached to France,

and Malta to Great Britain, but geographically they belong to Italy. Earthquakes which have been serious in two or three countries, and have originated on borderlands, may be prefixed with the name of either country. When a town has now or has had in the past more than one name, I have adopted that which is most familar in the English language. Where I have found the name of a place or district differently spelt in three modern atlases, as for example Provinces in China, and again spelt differently by sinologues, so far as possible I have adopted that of the authority quoted. I have not adopted it in cases where the spelling might make the name of the place unrecognisable, for example a city in Japan known as Kobe is sometimes spelt by sinologues as Kaube.

For a certain number of place names in China I have adopted the spelling given to me by Prof E. H. Parker, but for the majority of places in that country I have used that given in a geographical dictionary of the Cities and Towns of China by G. M. H. Playfair. In these we often find the suffix *Fu*. This means a prefecture or one of the largest sub-divisions of a province. In a few instances it has been difficult to identify the position of a town. For example, San José in South America may mean one out of at least 37 places. In that Continent in particular, we frequently meet with many towns and villages of the same name in a single country. Difficulties have also been occasioned in the identification of place names which during historical times have passed out of existence. To criticise my spelling is an easy matter. All I have tried to do has been to make a text intelligible. The atlases used have been Stieler, Harmsworth, Bartholomew, and Phillip's. A useful set of volumes in tracing out place names has been "The Gazetteer of the World" and its companion atlas. Localities which could not be found in these works have been referred to Mr. John Bolton, F.R.G.S., who has very kindly solved many difficulties.

Intensity of Earthquakes.—I have indicated the intensity of earthquakes by the Roman numerals I. II. III.

I. This means that an earthquake had an intensity sufficient to crack walls, break chimneys, to shatter old buildings or to produce slight cracks in the ground. It implies an acceleration or rapidity in the change of velocity of the surface of the ground of 1000mm. or 3ft. per sec. per sec. This means that each back and forth vibration of the ground corresponded to the jerk we should experience on a truck which commenced to move at the rate of 3ft. per sec. or when moving at that rate it was suddenly stopped. When this takes place the destructivity is usually confined to a town or village and the radius of the area effected will not exceed 5 miles.

II. With earthquakes of this intensity the acceleration is 1500mm. or 5ft. per sec. per sec., and its effect will have a radius of 20 miles. Buildings may be unroofed or shattered and

some may fall, the ground may be badly cracked in places and small landslips occur.

III. Earthquake with this intensity are those which destroyed towns and devastated districts. The ground has been faulted and fissured whilst from these openings water, mud, and sand may issue. In a hilly country landslips will be common. The acceleration may exceed 3000mm. or 10ft. per sec. per sec. Beyond the meisoseismic area up to a distance of 100 miles the effects produced may be similar to those of Class I.

The origin of all these earthquakes may generally be assumed to be along the line of fault or fracture in the earth's crust. Motion sufficient to cause destruction may extend to the right and left of such a line to distances of 100 miles. With earthquakes of Class I this distance may not exceed 5 miles. Should the fault or faults run parallel to a mountain range, which is commonly the case, it is rarely that violent motion will extend beyond such a barrier. Destruction frequently takes place along the length of the valleys. In consequence of these limitations and extensions, the area violently shaken is usually eliptical in form, the major axis of an elipse corresponding to the length of the fault or line from which the initial impulse or impulses have originated. Tele- or cryptoseismic motion which cannot be felt, but which can, with proper instruments, be recorded, does not appear to be limited by mountain barriers, but extends farther in the direction of the primary impulses or at right angles to fault lines than it does in the direction of their length. For example, the movement which caused destruction in Central California on April 18th, 1906, originated along a line of faulting 100 or more miles in length. This ran parallel to the coast of California. The most violent impulses occurred near to the centre of this line but their destructive effects were bounded on the East by the Sierras and other ranges about 150 miles distant. Very marked teleseisms however passed this barrier and extended in the direction of the initial effort round the world. The corresponding teleseismic records obtained from South America were, however, comparatively small. Notes on this subject will be found in *British Association Reports*, 1908, p. 74, and in *Nature*.

PRINCIPAL SOURCES OF INFORMATION.

Mallet's Catalogues.— The Catalogues of Mr. Robert Mallet are to be found in the British Association Reports for the years 1852-3-4. For each entry he gives one or more references to the sources from which he obtained his information. His first entry, 1606 B.C., which is given on the authority of Exodus, XIX., 19, and his last, 1842 Dec. 4, for which seven references are given from seven foreign publications. In the early part of his work we find many Biblical references which are intercalated with or followed by the names of ancient writers, amongst

whom we find Strabo, Herodotus, Livy, Thucydides, Justinus, Orosius, Julius Obsequens, Tacitus, Seneca, Theophanes and many others. Humboldt and V. Hoff are quoted for early and for late dates. Dom. Bouquet is often quoted. We also find references to Matthew of Westminster, the Edinburgh Encyclopædia, Bertrand, and Meran both in the "Collection Académique," The Gentleman's Magazine, Philosophical Transactions of the Royal Society, Silliman's Journal, various books of travel, the Gazette de France, Poggendorff's Annalen, Journ. des Débates, &c. At the end of his Report in 1858 he gives a catalogue of works covering 16 pp.

Catalogues and Memoirs by M. Alexis Perrey.—A list of Memoirs by M. Perrey, which are 59 in number, is given by Mallet in his British Association Report for 1858. In Perrey's bibliographical catalogues, published in 1855-56, there are references to 1887 different works on seismology. His earthquake catalogues published in "Mémoires de l'Académie de Dijon" and in "Bulletins de l'Académie Royale de Bruxelles" contain records from 1842-64. They are a continuation of the work of Mallet.

Catalogues of Dr. C. W. Fuchs.—These catalogues appear in the "Neues Jahrbuch fur Mineralogie, Geologie und Palæontologie" vols. 1866 to 1872. These refer to earthquakes of 1865 1871 inclusive. In the Jahrbuch der K. K. Geologischen Reichenstalt 1873 Band XXIII to 1877 Band XXVII we find registers of earthquakes for 1872 to 1876. Catalogues by Fuchs also appear in the "Mineralogische und Petrographische Mittheilungen," Neue Folge Band I to VIII, they contain references to earthquakes 1877 Jan. 2, to Nov. 6, 1884. This work, with the exception of the years between 1870 and 1877, is a continuation of Perrey's work, but it is by no means so complete.

There are many catalogues referring to earthquakes in general prior to Mallet, but I do not know of any subsequent to these collated by Fuchs. Since 1870 however, many catalogues referring to countries or regions have been compiled.

Italian Records.—Mario Baratta, in his "I Terremoti d'Italia," published by Fratelli Bocca, Turin, 1901, gives in a volume of 950 pp. accounts of 1,364 earthquakes which have shaken the Italian Peninsula. The date of the first is A.D. 1 and of the last 1898. Each earthquake is discussed and in many instances small maps are given showing the area disturbed. References to authorities occupy 103 pp.

Austrian (Central) Records.—These have been abstracted from a "Chronologische Ubersicht der Wiener Erdbeben" by P. v. Radics, see Die Erdbebenwarte 1908-1909 pp. 118-141.

Russian Records.—In the Memoirs of the Imperial Russian Geographical Society, vol. XXVI there is a catalogue of the earthquakes of the Russian Empire, by Mushketof and Orlof. It contains 2,574 entries. An abstract of this is given in the

British Association Report for 1910. Many of the disturbances extended into or originated in Chinese Territory.

Chinese Records. These have been obtained from several sources.

1. A catalogue by Ed. Biot, published in the "Annales de Chimie et de Physique." Tome II, 1841, p. 372. It contains 180 references.

2. A translation made by Mr. Shinobu Hirota of a list of Chinese earthquakes by Professor Omori, published in Chinese idiographs in the Proceedings of the Earthquake Investigation Committee of Japan, vol. XXIX, published in Tokio. In the British Association Report for 1908 an abstract of this catalogue and that of Biot has been given by Mr. Hirota.

3. A list abstracted and translated by Professor E. H. Parker from the Tung-Hwa-Lu. This work consists of about 100 vols., to read and index which occupied Professor Parker four years. The earthquake list comprises the period 1648-1872. The English translation is to be found in the British Association Report, 1909.

4. An abstract also made by S. Hirota from a "Catalogue des Tremblements de Terre, Signalés en Chine," par le R. P. Pierre Hoang, published by La Mission Catholique in Shanghai, 1909. This is a work of 298 pp. The first entry is 1767 B.C. and the last 1896 A.D. In it the same earthquake is repeatedly entered at the different places at which it was noted. For example, an earthquake which took place on July 24 and 25, 1668, is notified at 203 places. These are found in different parts of the volume.

The information derived from these different sources, together with those obtained from the Russian catalogue, are by no means always in agreement. It is often for example difficult to decide whether the date for an earthquake refers to its time of occurrence or to the time when it was notified at some Imperial City. For this reason some of the dates given in the present catalogue are not strictly in accordance with those published in the British Association Report.

Formosan Records.—Records relating to Formosa have been translated and abstracted by Mr. S. Hirota from a list of Formosan earthquakes published in idiographs by Mr. Kondo and Professor Ogawa (see Publications of the Earthquake Investigation Committee of Japan, vol. LIV).

Japanese Records.—The entries from Japan have been obtained from the following sources:—

1. From a catalogue by Professors Sekya and Omori, Proceedings of the Earthquake Investigation Committee of Japan, vol. XLVI. This, which is in Japanese, was abstracted by Mr. Hirota.

2. A Catalogue by Professor J. Milne published in the Transactions of the Seismological Society of Japan, vol. III.

p. 65. This is a compilation made from the translations of 64 different works in Japanese characters.

3. Catalogue of Japanese Earthquakes by Dr. Edmund Naumann, Mitt. d. Deutsch. Gesellschaft f. Natur u. Volkerkunde Ostasiens, Aug. 1878.

4. Destructive Earthquakes in Japan by Dr. T. Hattori, Transactions of the Asiatic Society of Japan, vol. VI, part 2.

Indian Records.—A great number of these have been taken from a list given by Thos. Oldham in the Memoirs of the Geological Survey of India, vol. XIX, part 3. Other references are to be found in the Records of the Geological Survey of India, vol. XVII, part 2, vol. XVIII, parts 3 & 4, vol. XXVI, part 2. The Journal of the Asiatic Society of Bengal, vol. XLVII, part 2, pp. 131-140. Proceedings of the Asiatic Society of Bengal, March 1883, pp. 60-66.

British Records.—These were taken from the "East Anglian Earthquake of 1884" by R. Meldola and W. White, published by the Essex Field Club and Macmillan & Co., London, and also from an excellent catalogue by W. Roper, printed in Lancaster, 1889. His list of references occupies two pages.

Icelandic Records.—These were abstracted by C. A. Gosch, Esq., from "Jardskjálftar á Sudurlandi" and "Landskjalftar á Islandi," by Thorvald Thoroddsen, Copenhagen, 1899-1905. A second abstract of this work was received from the Hon. Sir Allan Johnstone, British Minister in Denmark.

Central American Records.—These were taken from Tremblements de Terre et Eruptions Volcaniques au Centre-Amerique par F. de Montessus de Ballore, published at Dijon, Imprimerie et Lithographie Eugene Jobard, 9 Place Darcy, 1888. Emilio Böse in his "Temblor del 14 de Avril de 1907" published by the Instituto Geologico de Mexico, 1908, gives a list of destructive earthquakes which have occurred in or near to Acapulco.

Mexican Records.—A full list of destructive earthquakes which have taken place in Mexico is given by D. Juan Orozco y Berra, in Memorias de la Sociedad, Cientifica "Antonio Alzate," commencing in Tomo 1, números 6 y 7, ending in número 8. His first date is 1460 and his last 1899. An abstract in the Spanish language of this work I received through the Foreign Office from His Majesty's Representative in Mexico, His Excellency Reginald T. Tower, C.V.O. From 1899 to 1909 entries are given which are not found in the original work.

Peruvian Records.—Through the Foreign Office I received from Lucien J. Jerome, Acting Chargé d'Affaires, a list of earthquakes which have taken place in Peru, drawn up by Mr. H. Hope-Jones, a member of the Geographical Society of Lima.

Chilian Records. Through the Foreign Office and His Excellency H. C. Lowther, I received from Count F. de Montessus de Ballore a provisional list of destructive earthquakes of the Southern Andes, south of latitude 16° (S. Peru,

Chile, Bolivia, W. Argentina), see Report, British Association, 1910.

United States Records.– The records for the United States were chiefly collected by Prof. Harry Fielding Reid, Johns Hopkins University, Baltimore. He obtained his material from the following sources:– Holden's Catalogue of Earthquakes on the Pacific Coast, 1769 to 1897, Smithsonian Miscellaneous Collection, 1087, McAdie's Catalogue of Earthquakes on the Pacific Coast, 1897 to 1906, Smithsonian Miscellaneous Collection, part of Volume XLIX, Historical Notes on the Earthquakes of New England 1638 to 1869, William T. Brigham, Memoirs of Boston Society of Natural History, Volume II; "Note additionelle" by A. Lancaster, same; Rockwood's lists in the American Journal of Science; Dr. E. Deckert's paper on "Die Erdbebenherde, etc., von Nord-America, etc." in the "Gessellschaft für Erdkunde," Berlin, 1902; C. D. Perrine, Earthquakes in California, U.S. Geological Survey, 1895.

Prof. W. H. Hobbs, in his volume on "Earthquakes," describes certain heavy shocks.

West Indian Records.—Records of West Indian earthquakes have been largely taken from Government Reports printed in Jamaica, after the destructive earthquake of January 14, 1907.

Philippine Records.– A list of these has been published by the Rev. Miguel Saderra Masó, S.J., Assistant Director of the Weather Bureau in Manila. It contains an appendix for the Marianas Islands. The entries run from 1599 to 1909.

East Indian Records.—Long lists of earthquakes which have taken place in the Dutch East Indies have been published annually since the year 1865. They are by different authors and are to be found in the "Natuurkundig Tijdschrift voor Nederlandsch Indie."

Official Documents.—These are represented by a fairly large collection of letters, registers and other papers referring to destructive earthquakes in various parts of the world. They were brought together by the Foreign, Colonial, and India Offices, with the assistance of representatives of His Majesty's Government in Foreign Countries, Colonies and Indian Empire.

It is not for one moment supposed that this Catalogue is free from omissions and mistakes. Should a reader notice them I trust he will give me an opportunity of rectifying the same either in the appendix now in preparation or in some future publication.

JOHN MILNE.

SHIDE,
ISLE OF WIGHT,
ENGLAND,
FEBRUARY, 1912.

LIST OF ABBREVIATIONS.

B.	refers to	Baratta (Italy).
Bi.	,,	Biot (China).
Bo.	,,	Böse (Mexico).
C.V.	,,	Ch. Vélain (Italy).
D.	,,	Deckert (N. America).
F.	,,	Fuchs (General).
F.R.	,,	Fielding Reid (U.S.A.).
H.	,,	Hirota (China, Japan, Formosa).
H.J.	,,	Hope-Jones (Peru).
Ho.	,,	Hoang (China).
M.	,,	Mallet (General).
M.H.	,,	Maxwell Hall (Jamaica).
Mi.	,,	Milne (Japan).
Mon.	,,	Count Montessus de Ballore (Central and South America).
M. & O.	,,	Mushketoff & Orlof (Russia and Asia).
M. & W.	,,	Meldola & White (Britain).
N.	,,	The Journal "Nature" (General).
O.	,,	Omori (Japan and China).
Ol.	,,	T. Oldham (India).
O.B.	,,	Orozco y Berra (Mexico).
O.D.	,,	Official Documents (General).
O.N.T.	,,	Natuurkundig Tijdschrift voor Nederlandsch-Indie (Dutch East Indies).
P.	,,	Perrey (General).
Pa.	,,	Parker (China).
Pe.	,,	Perrine (California).
R.	,,	Roper (Britain).
Ra.	,,	Radics (Austria).
R.S.	,,	E. Rudolph and S. Szirtes (Colombia and Ecuador).
S.M.	,,	Sadera Maso (Philippines).
Th.	,,	Thoroddsen (Iceland).
Ti.	,,	"The Times" Newspaper (General).

I, II, III See p. 653.

Departments, Provinces, Counties, Districts are in parenthesis. Localities most severely shaken in Italics.

CATALOGUE OF DESTRUCTIVE EARTHQUAKES.

A.D.		
7	Nov. 10	China (Shensi), The Imperial City Changan, now Hsian and the northern district III H.
15		Italy, Rome II B.
17		Asia Minor III M.
18	Mar. 18	Italy, Reggio (Calabria), Sicily II B.
20		Italy, Rome I B.
25		Italy, Rome I B.
27		Italy, Rome I B.
33		Asia Minor, Bithynia and Palestine I M.
46	Oct. 23	China, Earthquake in forty-two counties, Nanyang (Honan) III H.
63		Italy, *Pompeii*, *Herculaneum*, Naples and other places in (Campania) III B.
68 or 69		Italy, Chietino in the (Abruzzi) II B.
77 or 78		Island of Cyprus III M.
79	Nov. 23	Italy (Campania), associated with the great eruption of Vesuvius which buried Pompeii I B.
85		Italy, Rome I B.
94		Italy, Rome II B.
103		England (Somersetshire) I M. & W.
109 or 110		Asia Minor, Galatia III M.
116		Italy, Rome II B.
119	Mar. 11	China (Honan), The Imperial City Loyang, Honan Fu. It was felt over forty-two counties III H.
121	Oct. 10	China, thirty-five counties were shaken and towns damaged III H.
128	Feb. 23	China (Kansu), The Imperial City and Hanyang, now Fuchiang, Kungchang Fu III H.
132		West of Scotland I M. & W.
138	Mar. 1	China (Kansu), Imperial City and Chinching in Lanchou Fu, Lungshi in Kungchang Fu III H.
141	Feb.	China (Kansu), Liangchou Fu, and six neighbouring districts III H.
177		Italy, Sicily III B.
180	Jan.	China (Kansu), Chiuchuan in Kanchou Fu III H.
204		England (Brecknockshire) I M. & W.
205		Wales, Caerleon II B.
234	Dec.	China (Honan), Loyang in Honan Fu II H.
238		Italy, Vicenza II B.
243 or 245		Italy, Verona II B.
254		Italy, Verona II B.
258		Italy, Rome III B.
260-61		Italy, *Vicenza*, Padua III B.
261		England (Cumberland) I M. & W.
262		Asia Minor, Libya I M.
286	March	China (Ssuchuan), Chushih of Chienwei in Chiating Fu and Yinping now Lungan Fu II H.
287		England, Worcester I M. & W.
288	June 7	China (Hunan), Changsha Fu and (Kuangtung), Nanhai, Canton and eight districts I H.
290	July 24	Italy, Lodi in (Lombardy) II B.
294	June	China (Ssuchuan), Chengtu III H.
294	Sept.	China, Shangku, Hsuanhua Fu, comprising the north part of (Chihli) III H.
294	Dec.	China (Honan), Kaifeng Fu, Nanyang Fu II H.
300		Italy, Atella in the Basilicata I B.
319	Jan.	China, Luling in Chian Fu in Yuchang, literary name of (Kiangsi); (Hupeh), Wuchang and Hsiling, now Yichang Fu II H.
319	June	China (Shansi), Chishan in Taiyuan Fu III H.
324 or 344		Italy (Campania) III B.
326		Italy, Sicily III B.
341		Italy I B.

A.D.		
341		Armenia I M. & O.
353		Scotland, Edinburgh II R.
357		Italy, Sicily II B.
362, 365, or 369		Italy, *Sicily* and Reggio (Calabria) III B.
365 or 369	July 21	Italy (Venetia), *Padua* and *Belluno ;* (Lombardy) ; Spoleto (Perugia) and Trevi (Umbria) III B.
369		Italy, Benevento II B.
375	July 21	Asia Minor, Nicia or Isnik III Ol.
376		Italy, Sicily, and violent in *Alexandria* in Egypt, Crete and Greece III B.
392		Italy, Rome I B.
412	Jan. to April	China (Kiangsi), Nankang Fu, Chian Fu I H.
416	Aug. 23	Japan (Kawachi) I Mi.
419		Palestine III M.
424		England (Cornwall) II M. & W.
427		Turkey, Constantinople III M.
441		Turkey, Constantinople III Ol.
441-55		Italy, Rome II B. & M.
457 ?		Asia Minor, Antioch III Ol.
462	Aug. 16	China, Yenchou in Lu and the south part of (Shantung) I H.
467		Italy, *Ravenna* (Emilia), Rome II B.
471 or 472		Asia Minor III M.
477		Italy, Rome II B.
483		England, Canterbury I M. & W.
494		Asia Minor, Syria, Laodicea or Latakia, Hierapolis, Tripoli and Agathicum III M.
499	August	China (Kiangsu), Chiangning Fu II H.
508		Italy. Rome II B.
518		Hungary (Dardania or Darda ?) III M.
528	Nov. 29	Asia Minor, Antioch III M.
534		England (Somersetshire) I M. & W.
543	Sept. 6	Throughout the then known world III M.
553		Italy, Rome II B.
553 or 555	Aug. 15	Turkey, Constantinople III M.
558	Dec. 25	Italy, Ancona and Numana now Umana III B.
573		China (Kansu), Liangchou Fu III H.
579 or 580		France, Bordeaux and Pyrenees I M.
599	May 28	Japan (Yamato) I Mi.
600		Italy (Tuscany) II B.
600	Dec. 13	All China (Shansi), *Hsian Fu ;* (Kansu), *Chin, Kungchang Fu ;* (Shantung), *Chining Fu*, *Wuting Fu*, *Laichou ;* (Hunan), *Changsha Fu ;* (Chehkiang), *Huchou Fu* III H. & Ho.
624	Aug. 15	China (Hupeh), Tsunchou now Chungyang in Wuchang Fu ; (Ssuchuan), Ningyuan Fu II H.
624		Italy (Tuscany) I B. Perhaps same as 600.
638	Feb. 15 or 16	China (Ssuchuan), Sung and Tsung, Lungan Fu II H.
646	Oct. 17	China (Kansu), Ling I H.
649	Sept. 12	China (Shansi), Hotung, comprising *Puchou Fu*, Pingting, Chiang, Ho, *Chieh* III H.
658	June	Asia Minor, Palestine and Syria I M.
659		Italy, Sicily III B.
672		Italy, Pistoia (Tuscany) I B.
675	Dec. 2	Japan (Yamato) I Mi.
677		Scotland, Glasgow I M. & W.
677	July 22	Japan (Yamato) I Mi.
678	Jan.	Japan, Kiushu III O.
678	July 19	Japan (Yamato) I Mi.
678		Italy, Arezzo and other cities (Tuscany) II B.
682	Sept. 19	Japan (Yamato) I Mi.
684	Nov. 16	Japan (Izu, Tosa) II Mi.
686	Sept.	China (Kansu), Kanchou Fu II H.
701	May 6	Japan (Tanba) I Mi.
705	July 2	China (Kiangsu), Yangchou Fu, Changchou Fu, Suchou Fu II H.
706	Sept.	China (Ssuchuan), Chentu Fu and six near districts II H.

A.D.		
712	Feb. 14	China (Shansi), Pingyang Fu, Fenchou Fu, Chiang III H.
713 ?	Feb. 28 or July 9	Asia Minor, Antioch III Ol.
715	June 30	Japan (Totomi, Mikawa) I Mi.
715		Asia Minor and Turkey, Isnik-Membeji in Armenia, Constantinople III M. & O.
729	June 1	China (Shensi), Lantien, Hsian II H.
734	Mar. 10	China (Kansu), Chinchou now Kungchang III H.
734	May 14	Japan, Nanto, Kinai and seven provinces II Mi.
737	Nov. 28	Japan (Osumi) II O.
738	Jan. 16	Palestine ? III Ol.
739		Italy, Rome I B.
740	Oct. 26	Turkey (Thrace), Constantinople and Asia Minor. In some places the sea retired III M.
742		Egypt and the desert of Saba in Arabia II M.
744	June 19	Japan (Higo) III Mi.
745 (ca)		Italy, Venice and surrounding Islands II B.
745	June 5	Japan (Mino) III Mi.
745	June 22	Japan (Settsu) I Mi.
746	Jan. 18	Syria and Palestine III M.
756	Nov. 27	China (Kansu), Hohsi, north-west of Ninghsia Fu, Changyeh in Kanchou and Chiuchuan now Suchou III H.
758		Italy III B.
762	May 30	Japan (Hida, Mino, Shinano) II Mi.
766	July 20	Japan (Osumi), Niijima formed III O.
775		Russia, Mozan and Daralagoz, 39°45N. 45°20E. (Siyunik) III M. & O.
777		China (Chihli), *Tzulu* in Paoting Fu, *Chaochou* and *Ningchin* III H.
778		Italy, Troviso and other parts (Venetia) III B.
780		Italy, Rome I B.
788	Feb. 13 to June 28	The whole of China. The most damage was done at *Kin* in (Hunan), *Fang* in Yunyang Fu (Hupeh) and The Imperial City Hsian in (Shensi) was destroyed III H.
793	April 30	Italy, Verona and neighbourhood II B.
793	May 27	China (Shensi), Imperial City Hsian, *Kuannei* and neighbouring districts ; (Shansi), Hochung Fu or Puchou Fu III H.
794		Egypt, Alexandria II M.
794	May 14	China (Shensi), Imperial City Hsian I H.
797		Italy, Sicily, also in Crete II B.
797	Sept. 9	Japan, Kioto I Mi.
801	April 30	Italy III B.
803		Russia, Khogot Mountains, Khoja near Tabriz ? II M. & O.
807	June 14	Japan, Kioto I Mi.
811		Scotland, St. Andrews, destroyed town and 1,400 people III R.
812	Sept.	China (Shensi), Imperial City Hsian I H.
814	April 1	China (Yunnan), Suichou in Lichiang Fu III H.
815		Italy, *Ravenna* and throughout Italy III B.
818	Aug. 10	Japan (Sagami, Musashi, Hitachi, Kotsuke, Shimotsuke) III Mi.
823	End of year	Germany, Aix-la-Chapelle II M.
827	Aug. 7	Japan, Kioto II Mi.
828	Dec. 2 or 3	Japan, Kioto I Mi.
829	April 7	Japan, Kioto I Mi.
830	Jan. 30	Japan (Uzen, Ugo), *Akita*. Duration 25 days III Mi.
833	Mar. 16	Japan, Kioto I Mi.
835	April 11	China (Shensi), Imperial City Changan or Hsian I H.
836	June 7	Japan, Kioto I Mi.
841	Mar. 5 or 7	Japan (Shinano, Izu), 94 shocks II Mi.
841	July 30	Japan (Izu) II O.
844		England, York I M. & W.
847	June	Italy, Benevento (Campania), *Isernia* (Molise), Rome and Ancona II B.

A.D.		
849	Oct. 20	China (Chihli). Shangtu, also called Luanching; also (Shansi), Chenwu or Kueihuacheng in Soping Fu; (Shensi), Hosi. E. of Chaoyi, Tiente, Lingwu in Hsienyang III H.
850	Nov. 12	Japan (Uzen, Ugo) III Mi.
853		Italy, Boiano (Molise) II B.
856	Mar. 13	Japan, Kioto (Yamashiro, Yamato, Kawachi. Izumi, Settsu) II Mi.
856	Dec. 13	Switzerland, Bale I M.
856	Dec.	Greece, Corinth; 45,000 lives lost III Ol.
856	Dec. 3 to 875, Jan. 1	Persia, Khorasan, Alamana III Ol. Mallet gives Hamadan also Syria.
859	Dec. 1	Japan, Kioto I O.
859		Asia Minor, Antioch, 1,500 houses fell; Laodicea or Latakia, also Bagdad, Damascus and Tarsus III M. & Ol.
863		Caucasia, neighbourhood of Erivan II M.
863	June 29	Japan (Etchu, Echigo) II Mi.
864	Nov. 14	Japan, Kioto; (Suruga, Kai) I Mi.
865	Dec.	China (Shansi), Chin, Chiang in Hotung, now Taiyuan Fu II H.
867	Mar. 9	China (Shansi), Hochung, Puchou Fu. Chin and Chiang, Taiyuan Fu III H.
867	June 21	Japan (Higo) I O.
868	July 30	Japan (Harima, Tanba, Settsu); Kioto II Mi.
869	July 9	Japan, Oshu; (Rikuzen) II Mi.
869		Russia, Dvin or Tovin III M. & O.
873	May 14	Japan, Kioto I Mi.
873	Oct. 10	Japan, Kioto I Mi.
875	Feb. 8	Japan, Kioto; (Satsuma) I Mi.
876	July 14	China (Chihli), Paoting Fu III H.
877	April 27	Japan, Kioto I Mi.
877	Nov. 2	Japan, Kioto I Mi.
878	Oct. 28	Japan (Sagami, Musashi, Awa. Kazusa, Shimosa, Hitachi, Kotsuke, Shimotsuke) III Mi.
879	March	China (Shensi), Imperial City Hsian also at Lantien I H.
880	May 14	Japan, Kioto; (Izumo) II Mi.
881	Jan. 13	Japan, Kioto I O.
881	Jan. 28	Japan, Kioto I Mi.
886	July 20	Japan, Kioto I Mi.
887	July 24	Japan, Kioto II Mi.
887	Aug. 22	Japan (Settsu, Shinano, Omi, Mino); Kioto III Mi.
890		Italy, Milan II B.
893 ?		Armenia, Dabil, Yamamahe and Yaman in Arabia III Ol.
893		Russia, Dvin or Tovin III M. & O.
894		Italy, Verona II B.
894		Caucasia, Erivan III M. & O.
896		Italy, Rome I B.
898	Aug. 22	Japan, Kioto I O.
925	Nov. 3	China (Honan), Honan Fu; (Shantung), Tungchang; (Kiangsu), Hsuchou Fu; (Anhui), Fengyang Fu III H.
932	July	China (Shansi), Taiyuan Fu II H.
932	Sept.	China (Kansu), Kungchang Fu III H.
934	July 11	Japan, Kioto II Mi.
935	May 25	Japan, Kioto I O.
938	May 17	Japan (Yamashiro), Kioto; (Yamato) II Mi.
949	May 4	China (Chihli), Yuting, now Yungping Fu, Tsuang in Tientsin Fu, Shen in Chingho and Pei in Kuangping Fu II H.
950, 951, or 952		Per multa Germaniæ et Galliæ loca II M.
953	Nov.	China (Honan), *Wei* or Changte Fu, Lo now Honan Fu; and (Chihli), Hsing, now Shunte Fu II H.
963	July 22	Italy, Sicily III B.
965	Oct. 18	Japan, Kioto I Mi.
968	Dec. 10	Italy, *Rossano* (Cosenza) and other places in (Calabria) II B.
972	Mar. 31	Japan, Kioto I Mi.
973	Oct. 25	Japan, Kioto II Mi.

A.D.		
973		Italy, Ancona I B.
976	May 12	Japan, Kioto II Mi.
976	July 17	Japan, Kioto III Mi.
977	Feb. 27	Japan, Kioto I Mi.
981		Italy, Benevento, Capua. II B. Perhaps the same as that of 990
981	Dec. 3	Japan, Kioto III Mi.
989		Greece and Turkey (Thrace), Constantinople II Ol., M. & O.
990		Italy, Benevento, Ariano, Frigento and Conza (Campania); *Ronza* (Basilicata) II B.
991		Italy, Borgo S. Sepolcro (Arezzo) II B.
991	Apl. 5-May 1	Asia Minor, Damascus; 1,000 houses fell III Ol.
994	Nov. 29	Japan, Kioto I Mi.
995		Armenia, *Chapajar*, 38°48N. 40°30E., *Alhakh* and *Amit*, same as Ami? III M. & O.
996	July 17	Japan, Kioto I Mi.
996	Oct.	China (Ssuchuan), Tung now Tzutung in Mien; Kuansi forming (Shensi); Hsia forming (Lower Shansi); (Kansu), Ling in Ninghsia Fu. Huan and Ching in Chingyang Fu III H.
996	Nov. 10	Japan, Kioto I O.
999	Oct.	China (Kiangsu), Changchou Fu, Wuchin and Yanghu II H.
1000	Mar. 29	Throughout the known world III M. & O.
1000		England (Cumberland) II M. & W. Same as above?
1001		Italy, Verona II B.
1004	Feb. 15	China (Honan), The Imperial City Kaifeng I H.
1004		Italy, Padua I B.
1004 or 1005		Italy (Campania), Monte Cassino I B.
1005		Italy, Arezzo and throughout (Tuscany) II B.
1007		Persia (Irak), Deinar? III M.
1010	Jan. 6 to Mar. 9	Turkey, Constantinople I M.
1011	August	China (Chihli), Chenching, now called Chengting I H.
1013		Iceland, Southland II Th.
1014		England (Cumberland) I M. & W.
1019		Scotland I M. & W.
1022	March	China (Shansi), Liao, Ying in Tatung Fu and Yuan in Chiang II H. Hoang gives April-May.
1027	April 11	Japan, Kioto I Mi.
1029		Syria, Damascus II M.
1035		Palestine, Jerusalem II M.
1037	Dec.	China (Shansi), Taichou, 759 lives lost, Pingchou, now Taiyuan, 1,890 lives lost and *Hsinchou*, 19,742 lives lost III H. Biot gives January 24, 1038.
1037	Dec. 18	Turkey, Constantinople II M.
1040	Oct. 16	Japan, Kioto I Mi.
1040	Dec. 13	Japan, Kioto I Mi.
1040	Feb. 2	Persia, Tabriz, also Smyrna and in Africa III M.
1041	Aug. 7 or 27	Japan (Owari, Totomi); Kioto I Mi. Omori gives August 25.
1043	June 18	China (Shansi), Hsinchou II H.
1045		Asia Minor, *Erzingan*, *Ami*, 39°34N. 39°E. and *Ekeghiaz* III M. & O.
1045	Sept. 3	China (Kuangtung), Canton; (Hunan), Kingnan, Yochou I H. & Ho.
1046	April 18	China (Shantung), Tengchou Fu I H.
1052		Persia (Chusestan): Ardistan and Irak? (Khorasan) I M.
1057	March to April	China (Chihli), *Yuchou*, Hsiungchou in Paoting Fu and Pachou in Shuntien Fu III H.
1058		Mesopotamia, Mosul II M.
1063		Syria, especially at Tripoli I M.
1064	April 11	Italy, Brescia, Milan and throughout (Lombardy) II B.
1065	June 13	Japan, Kioto I Mi.
1067	Oct. to Nov.	China (Fukien), Chuanchou, Changchou, Chienchou, Shaowu, Hsinghuachun; (Kuangtung), *Chaochou Fu* III H.
1068		China (Hunan), Yiyang in Chansha Fu I H.

A.D.		
1068		China (Shantung), Hui and Tunga in Yunchou now called Tungping in Taian Fu ; (Chihli), Tsangchou, *Chingchih* and *Mochou*, in Hochien Fu ; and *Hopei* in (Honan), comprising Changte Fu, Weihui Fu and Huaiching Fu III H.
1068	Dec. 31	China (Ssuchuan), Yingchou II H.
1069	Jan. 18	China (Chihli), Tsang in Tiensin Fu I H.
1069		Syria, especially at Ramleh and Egypt II M.
1070	Nov. 25	Japan, Kioto, Nara II Mi.
1082 or 1083	Dec. 6	Turkey, Constantinople II M.
1083	Oct. 18	Italy, Sicily, Catania III B.
1091	Sept. 22	Japan, Kioto III Mi.
1091	Nov. 2	France, Angers I M.
1091		Asia Minor, Edessa and Antioch III M. & O.
1092		Asia Minor, Antioch and Damascus I M. Same as above ?
1092	Nov. 1	China (Kansu), Lanchou, Cheniung ; (Shensi), Hsian Fu II H.
1092	Dec. 11	Japan, Kioto I Mi.
1093	Mar. 11	Japan, Kioto II Mi.
1093	Oct. 9	Italy, Venice I M. & B.
1095	Jan. 14 & 18	Italy, Benevento I B.
1095	Sept. 10	Italy, Venice and *Verona* I B.
1096	Dec. 11	Japan, Kioto II Mi.
1097	Aug. 21	Japan, Kioto I O.
1099	Feb. 16	Japan, Kioto II Mi.
1102	Jan. 15	China (Shansi), Chin, Hsi, Tai, Lan, Kelan, Paote, Ningwu, in Taiyuan Fu ; (Shensi), Shih, now Wupao and Weisheng. Suite Fu, N. and S. valley of the Yellow River III H.
1103	June 7	Japan, Kioto I Mi.
1104	April	Italy, Liguria I B.
1106		Italy, Venice II B.
1107 or 1114		England (Lincolnshire) I M. & W.
1110		England, Shrewsbury I R.
1111		Armenia (Van) II M. & O.
1111	May 6	Japan, Kioto I Mi
1114	Mar. 12	Asia Minor, Samosata, 37°30N., 38°32E. ; Ghisn-Mansur, 37°45N.38°20E. ; Khesun, 37°35N.37°51E. ; Marash, 37°36N. 36°52E. ; Kaben, 37°49N. 36°25E. ; and Sis, 37°28N. 35°50E. III M. & O.
1114		Asia Minor, Antioch and the country round II M.
1114		Italy, Viterbo in (Latium) II B.
1115		Sumatra and Java I M.
1117	Jan. 3	Italy (Lombardy, Venetia), Montecassino (Caserta) III B.
1120		Austria-Hungary " In valle Tridentina " I M.
1120	Sept.	England, Vale of Trent II R.
1122		Arabia I M.
1122		China (Chihli), Hsiungchou in Paoting Fu II H.
1124	Feb.	China (Honan), Kaifeng Fu I H.
1124	Mar. 25	Japan, Kioto I O.
1124		Persia (Khorasan) III M. & O.
1125	Aug. 30	China, in the Hsiho Circuit North of Kansu ; (Kansu), *Lunchou* III H.
1125	Oct. 11	Italy, *Benevento* (Frentana and Sannium) II B.
1127		Syria, Tyre II M.
1128	Feb. 15	China (Shensi), Hsian Fu II H.
1131		Armenia, *Ani* II M. & O.
1133	Aug. 4	England I M. & W.
1133	Sept. 2	China (Hunan), Pingchiang in Yochou Fu ; (Chehkiang), *Huchou* II H. Biot gives Oct. 12
1134		Armenia, Dogodoph? II M.
1135	May 2	Japan, Kioto I Mi.
1136	July 9	China (Chehkiang), Hangchou II H.
1137	Aug. 3	Japan, Kioto, I Mi.
1139		Mesopotamia, Hira, *Gansana ?* Aleppo and Ambar or Amla ? III M.
1139		Caucasia (Elizabetpol), Ganja, 40°40N. 46°20E., Kapassi Dagh, 40°22N. 46°20E. III M. & O.

A.D.		
1140	Feb. 1	Italy, Syracuse and felt throughout Sicily II B.
1143		Tibet, Tangut country II M. & O.
1143	Nov. 25	Japan, Kioto I O.
1144	Jan. 7	Japan, Kioto I O.
1144	June 22	Japan, Kioto I O.
1148		Italy, Florence II B.
1151		Iceland, Southwestland, eruption of Trolladyngjur, houses fell and lives lost II Th.
1154	Feb. 15	France (Burgundy), *Cluniacum* or Cluny ? II M.
1154	Oct. 17	Japan, Kioto I O.
1155	during winter	Asia Minor, Antioch, Damascus and Tripoli, 2,000 persons killed III M.
1155	Sept. 3	Japan, Kioto I Mi.
1156	Oct. 26 for 14 months	Syria, between Aleppo and Malatieh III M. & O. See Mallet, 1155.
1157	Jan. 19	Iceland, Southland, Hecla, eruption of II Th.
1158		Italy, Benevento and elsewhere II B.
1158		Asia Minor, Syria, Malatia, Antioch, Tripoli, Damascus, Aleppo, 20,000 perished III M.
1164		Iceland, Southland, Grimsnes, 19 lives lost II Th.
1164	Mar. 19	Japan, Kioto I Mi.
1165	Jan. 26	England (Norfolk, Suffolk and Cambridge) I R.
1165	July 20	Japan, Kioto I O.
1168		Asia Minor, Erzingan III M. & O.
1169	Jan. 24	China (Ssuchuan), Shihchuan, Suiting Fu II H.
1169	Feb. 4	Italy, *Catania*, Syracuse, throughout Sicily and (Calabria) III B.
1170	May 9	Italy (Latium), Ceccano I B.
1170	June 29	Syria, Hungary, Germany, Switzerland, Sicily and the north coast of Africa II M.
1170		Russia, Kief III M. & O.
1177	Nov. 19	Japan, Kioto, Nara I Mi.
1180	April 25	England, Nottingham II R.
1180	Dec. 22	Japan (Kii) II O.
1182		Asia Minor, Syria and Judaea II M.
1182		Iceland, Southland, 11 lives lost II Th.
1183	Aug. 15	Italy, *Verona* and many towns in (Lombardy) II B.
1183		Syria, Antioch, Damascus, Tripoli ; more than 20,000 victims III M.
1183	Oct. 31	Japan, Kioto I Mi.
1184	Feb. 5	Japan, Kioto I Mi.
1184	May 24	Italy, *Cosenza*, the valley of the Crati and in Reggio in (Calabria) II B.
1185	July 18	Japan, Kioto, Kamakura II Mi.
1185	Aug. 13	Japan, Kioto II O.
1185		England, Lincoln I M. & W.
1186	Oct. 3	Japan, Kioto III O.
1186	Middle of Sept.	Almost universal in Europe ; especially in England III M.
1186		England I M. & W. Same as above ?
1187	Nov. 13	Japan, Kioto I Mi.
1187	Nov. 20	Japan, Kioto I Mi.
1191	April 8	Japan, Kamakura I O.
1192		Italy, Arezzo and elsewhere in (Tuscany) II B.
1195	April 3	China (Honan), Kaifeng II H.
1196	May 3 or 4	[1198 according to Likosten and Frigius]. Poland (the Erzgebirge) and the greater part of Germany II M. & O.
1196	Autumn	Italy, Pistoia in (Tuscany) I B.
1198	May 2	Bohemia, village of Longaw II M.
1198		Italy, Pozzuoli in (Naples) II B.
1199	June 18	Japan, Kamakura I O.
1201	May 4	Austria, Vienna, Bohemia III Ra.
1201 or 1202		Asia Minor, Syria, Palestine, Mesopotamia and Cyprus II M.
1202	Feb. 29	Japan, Kamakura I O.
1204	Nov. 6	Japan, Kamakura I O.
1204		Egypt, Asia Minor, Syria, Mesopotamia, Irak, Cyprus and Sicily I M.

A.D.		
1205	Jan. 25	Japan, Kioto I O.
1205		Italy, Sicily II B.
1207	May 14	Japan, Kioto I O.
1208	Jan. 31	Japan, Kamakura I O.
1209	Dec. 6	China (Shansi), *Fushan* in Pingyang Fu; about 3,000 lives lost III H.
1210	Mar. 24	China (Chihli), Shuntien Fu II H. & Ho.
1211	Feb. 19	Japan, Kamakura I O.
1211	July 7	Iceland, Southland; eruption in sea south of Reykjanes II Th.
1211	Aug. 19	Japan, Kamakura I O.
1212		Italy, Venice II B.
1213	June 11	Japan, Kamakura I Mi.
1213	Oct. 9	Japan, Kioto I O.
1214	Mar. 26	Japan, Kamakura I O.
1214	May 20	Japan, Kamakura, Kioto I O.
1214	Nov. 2	Japan, Kamakura I O.
1215	Sept. 30	Japan, Kamakura II Mi.
1216		Italy, Subiaco in (Latium) II B.
1219	Jan. 11	Armenia, *Muskavank* I M. & O.
1219	June 2	China (Kansu), Pingliang and Chenjung in Pingliang Fu III H.
1221	Feb. 3	China (Chehkiang), Hangchou Fu I H.
1222	Dec. 25	Italy, *Brescia*, Milan, Bologna, Modena, Parma and throughout N. Italy III B.
1223		Italy, *Siponto* near the present Manfredonia and in other parts of (Foggia) III B.
1223	April 21	Italy, Brescia, Cremona II B.
1224	May 27	Japan, Kioto I Mi.
1225	Nov. 10	Japan, Kamakura I O.
1226	May 31	Japan, Kamakura I O.
1226	Sept. 1	Japan, Kamakura I O.
1227	Oct. 21	Japan, Kamakura I O.
1227	Dec. 22	Japan, Kamakura II O.
1227	Early in year	Italy, Maritime Alps III B.
1227	In winter	France, Rhone District (Bouches du Rhone), Aix III M.
1228	July	Italy, Ischia I B.
1229		Italy, Bologna and the Campagna II B.
1230	May 3	Russia, Kief, Pereiaslavl, Novgorod and environs of Rostof, Susdal and Valdimir I M. & O.
1231	June 1	Italy, *S. Germano*, *Montecassino* in (Latium), felt at Capua and in (Molise) III B.
1234	Oct. 10	Japan, Kioto I Mi.
1235	May 1	Japan, Kioto, Kamakura II Mi.
1235	Oct. 21	Japan, Kioto I O.
1237	June 24	Japan, Kioto I Mi.
1239	Dec. 15	Japan, Kamakura I O.
1240		Iceland, Southland; eruption outside Reykjanes II Th.
1241	Mar. 20	Japan, Kioto and Kamakura II Mi.
1241	May 22	Japan, Kamakura II O.
1243	June 18	Japan, Kamakura I O.
1245	Aug. 19	Japan, Kioto II Mi.
1246	Jan. 16	Japan, Kamakura I O.
1246		Island of Candia, Canea II M.
1246		England (Kent) I M. & W.
1246		Italy (Perugia), Spoleto II B.
1247	Jan. 13	Japan, Kioto, Kamakura I Mi.
1247	Nov. 13	Japan, Kioto I O.
1247	Dec. 31	Japan, Kamakura I O.
1247	Feb. 13	England, London II R.
1248		Italy, Valley of Moriana in (Savoy) III B.
1248	Dec. 21	West of England, Bath and Wells I M. & W.
1249	July 25	Italy, *Milan*, Verona I B.
1250	Aug. 24	Japan, Kamakura II O.
1253	April 1	Japan, Kamakura I O.
1253	July 14	Japan, Kamakura I O.
1255	Jan. 5	Japan, Kamakura I O.
1255	Beginning of year	Asia Minor, Arzengan or Erzingan in Siwas, district of Divrigi III M.

A.D.		
1257	Aug. 28	Japan, Kamakura; (Tsushima) II Mi.
1257	Sept. 17	Japan, Kamakura I O.
1257	Oct. 1	Japan, Kamakura II Mi.
1257	Dec. 22	Japan, Kamakura I O.
1260		Iceland, Northland, Island of Flatey. II Th.
1264	Nov. 2	Japan, Kioto I O.
1265	April 3	Japan, Kamakura I O.
1268	June 15	Japan, Kioto I Mi.
1268 or 1269		Italy, Ancona II B.
1268 or 1269	Nov. 3-4	Italy, Treviso, Feltre and Padua in (Venetia) II B.
1268		Asia Minor, in Cilicia, 60,000 killed III M.
1268		Asia Minor, Erzingan III M. & O. See above.
1272		Italy (Tuscany) I B.
1273		Italy (Basilicata) III B.
1273	April 5	Japan, Aizu II O.
1275	Sept. 11	England, Glastonbury I R.
1276	July 28 or 29	Italy, Lodi and environs, Milan, Bologna, Genoa II B.
1276		Roumania, Arcastia or Arcesci in the province of (Argesch), also at Cilath or Slatina ? II M.
1277		Italy, S. Sepolcro in (Arezzo) II B.
1277		Italy, Spoleto in (Perugia) II B.
1277	May 27	Austria, Constance I Ra.
1278	April 7	Italy, *Friuli* in Udine and Venice II B.
1279	April 24	Italy, *Friuli*, Cividale in Udine and *Venice* II B.
1279	April 30	Italy, *Forli* in (Emilia), Spoleto, Romagna and (The Marches) III B.
1281		Italy, Sicily I B.
1282	Jan. 17	Italy, *Venice* and Milan I B.
1283	At Easter	Caucasia, *Mtzkhet* II M.
1287	April 11	Italy, *Cremona*, Milan, Lodi I B.
1287	May	Asia Minor, Erzingan II, M. & O.
1289		Italy, Pistoia in (Tuscany) I B.
1290	Sept. 27	China (Chihli), Shangtu, also called Luanking; and (Fukien), *Wuping*, in Tingchou Fu, 100,000 lives lost III H.
1291	Sept.	China (Shansi), Pingyang Fu III H.
1292		Italy, Valley of Vivano or Bivona, Sicily and throughout the country II B.
1292		Italy, S. Sepolcro in (Arezzo) II B.
1293	May 20	Japan, Kamakura III Mi.
1293	July 11	Italy, Pistoia in (Tuscany) II B.
1294		Italy, Boiano in (Campobasso) II B.
1294		Italy, Siena I B.
1294		Iceland, Southland, Fliotshlid and Rangarvellir, eruption of Hecla III Th.
1295	Aug. 8	Austria, Vienna, Constance, Chur III Ra.
1295	Sept. 3-17	France, Tours, also Austria, Rhetic Alps II M.
1297		Italy, Capua I B.
1298		Italy, Pistoia and Arezzo II B.
1298		Italy, Ancona and *Umana* II B.
1298	Nov. 30	Italy, Rieti, Spoleto and throughout (Umbria) II B.
1298		Italy, Verona and environs II B.
1300		Italy, Larino, in (Campobasso) I B.
1300	Dec.	Iceland, Southland, earthquake with eruption of Hecla II Th.
End of 13th century		Central Asia, Karakorum III M.
1301		Italy, Cuneo in (Piedmont) II B.
1301		Italy, *Palermo* and throughout Sicily II B.
1302	Jan. or Feb.	Italy, Ischia II B.
1302	June 1	Japan, Kioto I Mi.
1303	Aug. 8	Alexandria and Acre, Peloponnesus, Candia and all the Adriatic Sea II M.
1303	Sept. 17	China (Shansi), Pingyang Fu, Taiyuan Fu, 100,000 houses destroyed and many people killed III H.
1304	Oct. 23	Italy, Vicenza, *Ferrara*, *Parma*, Piacenza, Venice II B.
1304	Feb.	China (Shansi), Pingyang Fu II H.
1305	April 3	Japan, Kioto I Mi.
1305	May 3	China (Shansi), Tatung Fu, 5,800 houses were destroyed and 1,400 people killed III H.

A.D.		
1305		Italy, Boiano in (Campobasso) II B.
1307 or 1309		Italy, Boiano in (Campobasso) II B.
1308	Jan. 25	Italy, Rimini II B.
1308		Iceland, Southland. 18 farms fell, six lives lost II Th.
1308		Caucasia, Karabagh II M. & O.
1308	June 28	China (Kansu), Ningyuan ; (Yunan), Chaotung Fu II H.
1310		Italy, *Reggio* in (Calabria) and throughout Sicily I B.
1311	Jan. 10 & 11	Iceland, Southland, eruption of Katla in Austurjokulls II Th.
1314	Sept. 14	China (Shansi, Honan) III H.
1315	Dec. 3	Italy, *Aquila* in (Abruzzi) and around II B.
1316	August	China (N. Shansi) I H.
1317	October	China, Lingpei II H.
1317	Feb. 21	Japan, Kioto II Mi.
1318	Nov. 14	England I R.
1319		Asia Minor, Armenia, in the provinces of (Ararat and Sini) *Ani* III M., M. & O.
1320	Oct. to Dec.	Italy, Siena I B.
1321		Italy, Venice II B.
1322		Italy, Pisa I B.
1323	Feb. 25	Italy, Bologna II B.
1325	Dec. 5	Japan, Kioto and neighbouring provinces II O.
1327	August	China (Kansu), *Tungwei* in Kungchang Fu ; (Shensi), Fenghsiang Fu and Hsingyuan, Hanchung Fu ; (Ssuchuan), Chentu ; (Hupeh), Shenchou and Chiangling in Chingchou II H.
1328	Dec. 1	Italy, Norcia, *Le Preci*, Montesanto and other places in (Umbria) III B.
1331	May	China (Chihli), Chenting Fu ; (Honan), Huaiching Fu II H.
1331	July 28	Japan, Kii II Mi.
1331	Aug. 19	Japan (Suruga) II Mi.
1334	Sept. 14	China, Imperial City Pekin. A cock crowed before the earthquake commenced III H.
1334	Sept. 25	Japan, Kioto I Mi.
1334	Dec. 4-5	Italy, Verona II B.
1335	Jan. 8	Japan, Kioto I Mi.
1336	Jan. 12	China (Anhui), Anching, Susung, Taihu, Hsunshan, also at Luchou ; (Hupeh), Chichou, Huangchou Fu III H.
1337	Sep. 9	China (Chihli), Imperial City Pekin, Shunchou, near Shunyi, Lungching, Huailai, Hsuante, now Hsuanhua III H.
1338	July	China (Chihli), Hsinchou, Shuntien Fu ; Mount Ling was displaced II H.
1338	Aug. 2	China (Chihli), Hsuanhua Fu II H.
1338	Aug. 5	Japan, Kioto I Mi.
1338	August	China (Kansu), a mountain was displaced at Kungchang II H.
1339	May 22	Iceland, Arnessysla, Rangarvallasysla, Skeid, Floi, Holt ; a great many farms fell III Th.
1339	Oct. 15	Japan, Kioto I O.
1340	Mar. 3	Japan, Kioto I O.
1341	April 2	Japan, Kamakura I O.
1342	May 30	China (Shansi), Pingchin in Chining, now Taiyuan III H.
1343	Nov. 24	Malta III O.D.
1344	Middle of autumn	Southern part of Iceland and the province of (Guldalen) in Norway, on the R. Gulo III M.
1345	Jan. 28	Germany III Ro.
1345	Sept. 12 or Dec. 22 ?	Italy, S. Sepolcro, Arezzo and Florence II B.
1346	Feb. 22	Italy and throughout the world, especially in Alexandria II B.
1346	March	China, all (Shantung) II H.
1346	April	China (Shantung), Kaoyuan in Chingchou Fu II H.
1346	Aug. 29	Japan, Kioto I O.
1346	Nov. 24 & 25	Switzerland, especially at Bâle II M.
1346		Turkey, Constantinople II M.
1347	Mar. 10	Japan, Kioto I O.

A.D.		
1347	Mar. to June	China (Shantung), Lintzu, Chingchou Fu: (Shansi), Hotung now called Puchou and Pingyang III H.
1347	Aug. 12	Japan, Kioto I O.
1348	Jan. 25	Italy (Venetia); Austria (Styria, Carinthia), *Villach*, Gorz III B., M. & O., Ra.
1348		Italy, France, Roccabigliera, Lantosca and Bollena in (Nice) II B.
1349	Sept. 9 or 10	Italy, *Aquila* (Molise), and elsewhere in (Abruzzi) and in Sannium III B.
1349	Sept. 10	Japan, Kioto I O.
1350	June 28	Japan, Kioto I Mi.
1350	Aug. 5	Japan, Kioto I Mi.
1351	Mar. 15	Japan, Kioto I Mi.
1351	May	China (Shansi), Fen, Hsin, Wenshui, Pingchin, Yutzu and Shouyang in Taiyuan Fu, Yushe of Liao in Chinning now Pingyang Fu; also (Honan), Honei, Hsiuwu, Mengchou in Huaiching Fu III H.
1352	April 18	China (Shensi), this comprised part of (Kansu), the north-west part of (Ssuchuan), and the present (Shensi). Most damage done at *Chuanglang*, *Tinghsi* in Liangchou Fu, Chingning in Pingliang Fu, and Huichou, now Huan in Chingyang (Kansu) III H.
1352	Dec. 25	Italy, *La Rocca d'Elci*, Arezzo, S. Sepolcro, Citta di Castello in (Umbria) III B.
1354	Beginning of spring	Turkey, all the coast of Thrace II M.
1354	Dec.	China (Anhui), Ningkou Fu; (Kiangsu), Huaian Fu II H.
1355	Sept.	Switzerland and Germany, Bale and Strasburg II M.
1356	Aug. 24	Portugal, Lisbon II M.
1356	Oct. 18	Germany, all the upper Rhine, especially at Strasburg and Bale, district of Constance, Lausanne, Berne and the borders of Bavaria II M.
1358	Oct. 7	Japan, Kioto II Mi.
1358		Italy, S. Sepolcro in (Umbria) II B.
1361	July 17	Italy, *Ascoli*, Canosa and S. Agata in (Apulia) III B.
1361	July 22	Japan, Kioto II Mi.
1361	Aug. 1	Japan (Kii, Settsu, Yamato) and Kioto II O.
1361	Aug. 3	Japan, Kinai; (Awa) II O.
1361	Dec. 19	Japan, Kioto I O.
1361	Dec. 27	Italy, Siena II B.
1362	June 9	Japan, Kioto I Mi.
1363	Mar. 27	Japan, Kioto I Mi.
1363		Armenia Mush I M. & O.
1365	April 7	Italy, Bologna II B.
1366	August	China (Shansi), Hsin, Lin, Shih in Hsukao of Taiyuan and Hsiaoyi, Pingyao in Fenchou III H.
1366	Dec. 25	China (Honan), Kung in Honan Fu I H.
1367	Feb. 16	Japan, Kioto I O.
1367	Mar. 25	Japan, Kioto I O.
1367	Sept. 21	Italy, Verona II B.
1367	Sept. 23	Japan, Kioto I O.
1368	June 16	China (Shansi, Shensi, Kansu) III H.
1369	Feb. 1-2	Italy, Alessandria I B.
1369	Aug. 29	Japan, Kioto I Mi.
1369	Nov. 26	Italy, Monza in (Milan) I B.
1370		Iceland, Southland, Olfus; twelve farms fell, six lives lost II Th.
1371	April 13	Japan, Kioto I O.
1371	Oct. 14	Japan, Kioto I O.
1372	May 24	China (Kuangsi), Wuchou Fu, Pingli Fu II H.
1372	Aug. 16	China (Kiangsu), The Imperial City Nankin II H.
1372	Sept. 6	China (N. Shansi), Taiyuan Fu II H.
1372		Spain, district of Ribagorca in (Aragon) I M.
1373	May 2	Japan, Kioto I O.
1373	Dec. 14	Japan, Kioto I O.
1374	Dec. 8	Armenia, Erzingan II M. & O.
1375	May 23	Japan, Aizu II O.
1376	March	Italy, Vicenza I B.
1376	May 14	Japan, Kioto I Mi.

A.D.		
1378	April 30	China, Ninghsia in north (Kansu) I H.
1378	Nov. 27	Japan, Kioto I O.
1379	Nov. 26	Japan, Kioto I O.
1380		England, Canterbury I M. & W.
1382	Jan. 3	China (Kansu), Lanchou Fu; (Kuangtung), Kuangchou Fu; (Fukien), Fuchou Fu II H.
1382	May 21	England generally I M. & W.
1383	June 3	Japan, Kioto I O.
1383	August	Asia Minor, at Mytilene, 500 persons perished III M.
1388	Feb. 5	Japan, Aizu II O.
1389	Spring	Italy, Fano, in the (Marches) I B.
1389	Aug. 20	Italy, Moggio in Udine and Belluno I B.
1389	October	Italy, *S. Sepolcro*, Citta di Castello in (Umbria) II B.
1389	Oct. 3	Japan, Kioto I O.
1389-90		Iceland, Southland, with eruptions of Hecla, Trolladyugjar and Sidu Jokull II Th.
1391	Nov. 11	Japan, Kioto I Mi.
1391		Iceland, South Country, Grimsnes, Olfus, Floi; fourteen farms fell III Th.
1393	Summer	Italy, Galeata in (Tuscany); Bologna I B.
1395	Mar. 24	Japan, Kioto I O.
1395	Dec. 18	Spain, Province of (Valencia) and at Tortosa II M.
1396		Italy, Nardo and (Lecce) I B.
1397	Dec. 26	Italy, Bergamo and throughout (Lombardy) II B.
1398	April 3	Italy (Abruzzi), Aquila I B.
1399	July 20	Italy, *Modena*, Bologna, Ferrara II B.
1400		Japan, Kioto and (Iga, Ise) II O.
1402	Feb.	Japan, Kioto II Mi.
1402		Syria; many towns ruined III M.
1402	Dec. 5	Italy (Emilia), Forli II B.
1403	Jan.	Italy, *Verona*, Belluno and throughout (Lombardy) II B.
1403	Sept. 6	Italy, Friuli in (Udine) II B.
1404	Jan. 2	China, Pekin; (Shansi), Taiyuan Fu; (Kansu), Ninghsia Fu I H.
1404	Dec. 17	China, Nankin, The Imperial City; (Shantung), Chinan Fu; (Honan), Kaifeng Fu II H.
1405	Dec. 20	Japan, Kioto I O.
1407	Feb. 12	Japan, Kioto, *Aizu* III Mi.
1408	Jan. 21	Japan (Settsu), with sea waves II O.
1408		Italy, Florence I B.
1408	Nov. 26	Japan, Kioto I O.
1409	Nov. 15	Italy, Parma I B.
1410		Italy, Catania I B.
1410	Mar. 11	Japan, Kioto I Mi.
1410	June 10	Italy, Verona II B.
1411	June 6	Japan, Kioto I O.
1411	Dec. 24	Japan, Kioto I O.
1412	April 19	Japan, Kioto I O.
1413	Aug. 8	Italy, Siena I B. & M.
1413	Dec. 17	Japan, Kioto I O.
1414		Italy, Vieste in (Foggia) II B.
1414	Aug. 3	Italy, S. Sepolcro, Florence, Arezzo, other places in (Tuscany) and in Bologna II M. & B.
1418	April 7	Austria-Hungary, throughout Dalmatia I M.
1419	Oct. 28	Japan, Kioto II Mi.
1420	Aug. 15	Japan, Kioto I O.
1420	Sept. 26	Japan, (Sagami, Musashi, Awa, Kazusa, Shimosa, Hitachi, Kotsuke, Shimotsuke) III O.
1420		Spain, Province of (Catalonia), *Amer* II M.
1425	Mar. 8	China, Nankin; (Anhui), Luchou Fu II H.
1425		Italy, Rome I B.
1425	Aug. 10	Italy, *Ferrara* and Venice I B.
1425	Aug. 10-24	Japan, Kioto II O.
1425	Dec. 14	Japan, Kioto I Mi.
1426	Aug. 15	China, Pekin and Nankin II H.
1426	Oct. 31	Japan, Kioto I O.
1427	May 15	Spain, especially at Olot in (Catalonia), also at Montpellier in France II M.
1428	Feb. 2	Ditto II M.

A.D.		
1428	July 3	Italy, Forli and Cesena in (Emilia) and in (Romagna) II B.
1428	Oct. 4	Japan, Kioto I O.
1428	Dec. 13	Switzerland, Bâle and the country round I M.
1429		Italy, Venice II B.
1431	April 24	Spain (Catalonia, Aragon and Roussillon), also Ciudad Real in (New Castile) I M.
1433	Feb. 23	Japan (Ise, Omi) II O.
1433	May 4	Italy, *Bologna*, Modena and Forli I B.
1433	Oct. 29	Japan (Shimosa, Sagami), Kamakura ; Kioto and Aizu II Mi. Omori gives Nov. 7.
1436	March	Italy, Siena I B.
1436	Aug. 30	Japan, Aizu II O.
1436	End of March	Italy, Siena I M. & B.
1438	June 10	Italy, Parma, Piacenza and environs II B.
1439	Jan. 22	Japan, Kioto II O.
1440	Oct. 3	Japan, Aizu, Kioto I Mi.
1440	Oct. 26	China (Kansu), Chuanglang in Liangchou Fu III H.
1442	March 1	Japan, Kioto I Mi.
1442	Dec. 1	Japan (Kotsuke) I O.
1442		Italy, Sicily II B.
1443	June 5	Austria and Bohemia, *Glatz* in Silesia, Poland and especially Hungary III M. & Ra.
1444	May 14	Japan, Kioto I Mi.
1445	Jan. 9	Japan, Kioto III O.
1447	Aug. 14	Japan, Kioto I O.
1448	April 26	Italy, Citta di Castello in (Umbria) II B.
1448		Italy, Naples III B.
1448		All Japan. Three large earthquakes III Mi.
1449	May 7	Japan (Yamashiro), Kioto ; (Yamato) III Mi.
1450		Italy, Sicily II B.
1452	Jan. 10	Japan, Kamakura I O.
1452	Sept. 5	Japan, Kioto I O.
1452	Sept.	Italy, Alessandria in (Milan) I B.
1453	Sept. 15	Japan, Kioto I Mi.
1453	Sept. 28	Italy, Florence and environs III B.
1454	Dec. 21	Japan, Kotsuke I Mi.
1455	Jan. 7	Japan, Kamakura I O.
1455	Feb. 3	Italy, Spilimbergo and elsewhere in (Udine) I B.
1455	Dec. 20	Italy, *Bologna* and Modena I B.
1456	Feb. 6	Japan, Kioto I Mi.
1456	Aug. 22	Italy, Siena II B.
1456	Dec. 5	Italy, all the south, especially *Brindisi*, *Ariano*, Avellino and Naples III B.
1457	April 26	Italy, Citta di Castello in (Umbria) II B.
1458	Feb. 25	Japan, Kioto I O.
1458	April 7	Japan, Kioto I O.
1458		Armenia, Erzingan III M. & O.
1460	Mar. 12	Japan, Kioto I O.
1460	June 23	Japan, Kioto I O.
1460	Nov. 19	Japan, Kioto I Mi.
1460		Mexico, Valley of Mexico III O.B.
1461	June & August	Italy, Buccino in (Salerno) II B.
1461	Nov. 20	Italy, Aquila II M.
1461	Nov. 27	Italy, *Aquila*, *Teramo* in (Abruzzi) and in Perugia III B.
1463	Sept.	Italy, Florence I B.
1464	May 22	Japan, Kioto I O.
1465	April	Italy, Reggio in (Emilia) I B.
1465	May 3	China (Chihli), Tiensin ; also (Ssuchuan), Chengtu Fu II H.
1466	Jan. 14	Italy (Salerno and Basilicata) II B.
1466	May 29	Japan (Yamashiro, Yamato) II O.
1466	Summer	France, Soissons and the neighbourhood II M.
1467	Feb. 3	Japan, Kioto I Mi.
1467	April 10	Japan, Kioto, Nara I O.
1467	June 27	China (Chihli), Hsuanhua Fu ; (Shansi), Tatung Fu, *Sochou* in Soping Fu and *Weiyuen* III H.
1467	July	Italy, Argenta in Ferrara II B.
1467	Sept. 3	Italy, Siena I B.
1468	Mar. 9	Japan, Kioto I O.

A.D.		
1468	July 6	Italy, Rimini II B.
1469		Mexico, Xochitepec on coast (Vera Cruz) III O. B.
1469	Spring	Greece, Zante, Cephalonia III P.
1470	Jan. 9	China (Honan), Juning Fu; (Hupeh), Yochou Fu, Wuchang Fu, Hanyang Fu II H.
1470	April 15	Italy, Casio Castello in (Bologna) I B.
1471	Feb. 5	Japan, Kioto, Nara I O.
1472	May 14	Italy, Friuli in (Udine) I B.
1473	May 7	Italy, *Milan*, Pavia and Piacenza III B.
1474	Mar. 11	Italy, Modena I B.
1474	Oct. 24	China (Yunnan), Hoching in Lichiang Fu III H. M. & O. give Oct. 27.
1474	August	Italy, Ancona I B.
1474	Nov. 24	China (Kansu), Tashaching in Lingchou, Chingyang Fu II H.
1474		Mexico, Valley of Mexico III O. B.
1474	Winter	Japan, Kioto I O.
1475	May 20	Japan, Aizu II O.
1477	Feb. 18 or Mar. 19	China (Kansu), Lintao and Kungchang II H.
1477	May 13	China (Kansu), Kanchou, Ninghsia, Liangchou; (Shensi), Yulin and (Shantung), Yichou III H.
1477	Dec. 20	Japan, Kioto I O.
1478	August	China (Ssuchuan), Chengtu III H.
1479	Sept. 27	Japan, Aizu II O.
1479	Oct. 10	Italy (Emilia), Forli I B.
1480		Italy, *Monteprandone* and elsewhere in (Ascoli Piceno) I B.
1480		England, Norwich I M. & W.
1481	Mar. 10	China (Kiangsu), Nankin, Huaian Fu, Yangchou Fu; (Anhui), Fengyang Fu, Luchou Fu, Hochou, Yingchou Fu; (Shantung), Yenchou Fu; (Honan), Honan Fu III H., M. & O.
1481	April 26	Japan, Nara I O.
1481	May	Italy (Tuscany), Fivizzano II B.
1482		Asia Minor, Armenia, Erzingan III M. & O.
1483	Feb. 16	Japan, Nara I O.
1483	Aug. 11	Italy (Emilia), Forli, Cesena II B.
1484		Italy (Emilia), Cervia in Ravenna II B.
1484	Jan. 19-20	Italy, Lamentana, Castelnuovo and other places in (Latium) I B.
1484	Jan. 29	China (Chihli), Imperial City Pekin, Yungping, Hsuanhua and Liaotung III H.
1485	April 17	China (Kansu), Kuyuan in Pinglian Fu, Lanho, Tao and Min in Kungchang Fu II H.
1485	April 27	China (Chihli), Chichou, Shuntien Fu, Tsunhua II H.
1485	Oct. 16	China (Kuangtung), Lienchou; (Kuangsi), Wuchou I H.
1486	June 6	Japan, Nara, Kioto I O.
1486	July 20	China (Shensi), Ningchiang in Hanchung Fu, Paochi in Fenhsiang Fu II H.
1486	Oct. 6	China (Ssuchuan), Chengtu Fu I H.
1487	Jan. 11	Italy, Verona II B.
1487	Dec.	Italy, Padua I B.
1488	July 31	Italy, Pozzuoli in (Naples) II B.
1488	Sept. 16	China (Ssuchuan), Han, Mou, Chengtu Fu III H.
1488	Sept. 22	China (Chihli), Hsuanhua Fu II H.
1489	May 29	Japan, Aizu II O.
1489	August 27-30	Japan, Kioto I O.
1489	Sept. 11	Japan, Kioto I O.
1489		Italy, S. Sepolcro in (Arezzo) II B.
1490		Italy, Alcara in (Messina) I B.
1491	End of Oct.	Greece, in the Archipelago, especially in the island of Cos. 5,000 people perished III M.
1492		Italy, Verona II B.
1492	June 29	Japan, Kioto I O.
1492	July 19	Japan, Aizu III O.
1493	Aug. 18	Japan, Kioto, Aizu I Mi.
1493	Nov. 17	Japan, Kioto, Nara I Mi.

A.D.		
1493	Dec. 20	Japan, Kioto, Nara I O.
1494	Feb. 21	Japan, Aizu I O.
1494	Mar. 25	China (Yunnan), Chuching Fu; also at Pekin and Nankin III H.
1494	May 28	Italy, Messina II B.
1494	June 10	Japan, *Nara*, Kioto II Mi.
1494	June 13	Italy, Lantosca, Roccabigliera, Bollena and throughout Nice II B.
1495	April 10	China (Kansu), Ninghsia II H.
1495	Sept. 12	Japan, Kamakura I Mi.
1495	Dec. 13	Italy, *Ferrara* and Venice I B.
1496		Mexico, Valley of Mexico III O. B.
1496		China, Pekin and Nankin I H.
1497	Nov. 21	Japan, Kioto I O.
1497		China (Chihli), Chenting Fu now forming Chengting in Chinho; (Shansi), Taiyuan Fu, *Tunliu* in Luan Fu; (Shensi), Yulin Fu; (Kansu), Chenfan in Liangchou Fu, Lingchou, Ninghsia Fu II H.
1498	July 9	All Japan; sea waves III Mi.
1498	Sept. 20	Japan, whole of Hondo, sea waves at (Ise, Kii, Mikawa, Totomi, Suruga, Izu, Sagami) III Mi.
1498	Dec. 9	Japan, Kioto, Nara I O.
1499	Nov. 19	Italy, Messina II B.
1500	January	Italy, Naples and Messina II B.
1500	July 10	Japan (Totomi); sea waves III O.
1500	Nov. 18	China, Pekin, Nankin; (Anhui), Fengyang I H.
1501	Jan. 19	China (Shensi), Yenan Fu, Hua, Hsingyang Fu, *Chaoyi*, Hsienyang in Hsian Fu, Tungkuan in Tungchou Fu; (Shansi), Puchou Fu; (Kansu), Chingyang III H.
1501	Feb. 15	China (Fukien), Fuchou Fu, Hsinghua Fu, Chuanchou Fu, Changchou Fu II H.
1501	Mar. 5 to April 2	China (Shansi), Puchou Fu, about 20 shocks I H., Ho., M. & O.
1501	June 5	Italy, *Modena* and environs, Parma, Bologna, Ferrara II B.
1502		Italy, Cittaducale in (Aquila) II B.
1502	Jan. 23	Italy, Urbino I B.
1502	May or Sept. 23	Italy, Cuneo in (Piedmont) II B.
1502	Jan. 28	Japan (Echigo) III O.
1502	Oct. 17	China (Kiangsu), Nankin, Hsuchou Fu; (Chihli), Taming Fu, Shunte Fu; (Shantung), Chinan Fu, Tunchang Fu, Yenchou Fu and *Puchou* in Tsaochou Fu III H.
1502	Nov. 24	China (Shansi), So, Tai, Ying, Shanyin, Yangchu, Mayi in Tatung Fu II H.
1504	April 5	Spain, in (Andalusia), especially at Carmona, Seville and Triana on the Guadalquivir II M.
1504	End of autumn	Portugal I M.
1504	June	Afghanistan, the high land of Kabul I M.
1504		Italy, Venice II B.
1504-5	Dec.-Jan.	Italy, *Bologna*, Brescia, Ferrara II B.
1505	July 6	Afghanistan, Kabul and Persia III Ol.
1505	July 11	China (Kansu), Ninghsia I H.
1505	Oct. 9-10	China (Chehkiang), Hangchou Fu, Chiahsing Fu, Shaohsing Fu, Ningpo Fu; (Kiangsu), Nankin, Suchou Fu, Sungchiang Fu, Changchou Fu, Chenchiang Fu; (Anhui), Ningkuo Fu, Taiping Fu I H.
1505	Oct. 16	China (Shansi), Puchou, *Anyi* in Chieh, Chiang; (Chihli), *Wanchuan* in Hsuanhua Fu III H.
1506	Mar. 17 to 19	China (Shensi), Tungchou Fu I H.
1506	April 26	China (Yunnan), Yunnan Fu II H.
1506	Aug. 26	China (Shantung), Aoshanwei, Laichou Fu II H.
1507	Mar. 31	Japan (Higo) III O.
1507	Nov. 4	China (Yunnan), Anchou, Hsinhsingchou in Yunnan Fu III H.
1509	Feb. 25	Italy, *Reggio* in (Calabria) and in Sicily, especially at Messina III B.
1509	April 19	Italy, Solarolo, Faenza in (Emilia) II B.
1509	May 26	China (Hupeh), Wuchang Fu I H.

A.D.		
1509	Sept. 14	Turkey, Constantinople and all the Turkish dominions in Europe and Asia Minor, *Tschorum*, *Gallipoli*, and *Demiloka*. The sea came over the walls at Constantinople and Galata III M.
1510	February	Italy, Alessandria in (Milan) II B.
1510	June 10	Bavaria, Nordlingen ; 2,000 perished III M.
1510	July 26	Iceland, Skalholt, 20 miles W. of Hecla, eruption of Hecla I Th.
1510	Sept. 11	Japan, Kioto (Yamashiro, Mikawa, Yamato, Kawachi, Izumi, Settsu) III Mi.
1510	Oct. 1	Japan (Totomi), with sea waves II Mi.
1511	Mar. 26	Italy, Cividale in (Friuli), Udine and many towns in (Venetia) and Triest III B.
1511	Aug. 8	Italy, Cividale II B.
1511	Sept. 9	Japan (Settsu, Hitachi) III Mi.
1511	Nov. 17	China (Yunnan), Tengchuan in Tali Fu, *Chienchuan* and *Hoching* in Lichiang Fu III H.
1511	Dec. 2	China (Chihli), Pekin, Paoting Fu, Hochien Fu ; (Shantung), Wuting Fu II H.
1512	Feb. 23	Japan, Kioto I Mi.
1512	June 21	Japan (Yamashiro) II Mi.
1512	June 22	China (Yunnan), Chuhsiung Fu I H.
1512	Oct. 7	China (Yunnan), Tengchung now Tengyuen in Yungchang Fu III H.
1512		Mexico, Valley of Mexico I O.B.
1513		Mexico, Valley of Mexico II O.B.
1514	Jan. 13	Japan, Kioto I O.
1514	April 16	Greece, Zante III P.
1514	May 2	Japan, Kioto I Mi.
1514	Oct. 20	China (Ssuchuan), Hsuchou Fu ; (Shansi), Yutzu, Tai, Ping in Taiyuan Fu, Tatung Fu and ten more towns II H.
1515	June 17	China (Yunnan), Yunnan Fu, Chaochou in Tali Fu and Yungning now Nanning in Chuching Fu III H.
1516	Aug. 20	Japan (Kai) II O.
1516	Oct. 20	China, Nankin ; (Hupeh), Wuchang Fu I H.
1517	Jan. 5	China (Yunnan), Chuhsiung in Tali Fu, Menghua I H.
1517	May 9	China (Kiangsi), Fuchou Fu ; (Shantung), Chinning Fu ; (Chehkiang), Hangchou Fu I H.
1517	June 18	Japan, Kioto I O.
1517	July 18	Japan, Aizu II O.
1517	July 12	China (Yunnan), Hosi, Hsio, Tunghai in Linan Fu and Hsinhsing in Chengchiang Fu III H.
1518	July 8	China (Yunnan), Tali Fu, Menghua I H.
1519	April 27	Japan, Kioto I O.
1520	Mar. 26	China (Yunnan), Anning in Yunnan Fu, Hoching in Lichiang Fu, Yao in Chuhsiung Fu, Pinchuan in Tali Fu and *Menghua* III H.
1520	Sept. 17	China (Yunnan), Chingtung II H.
1520	Sept. 21	China (Shantung), Chinan Fu, Tungchang Fu ; (Honan), Kaifeng Fu I H.
1520	Dec. 1	Japan, Kioto I O.
1520		Chile, provinces in south Chile I Mon.
1521	Oct. 21	Japan, Nara I O.
1521	Nov. 28	Japan, Kioto, Nara I O.
1523	January	China, Nankin ; (Shantung, Honan and Shensi), Hsian Fu II H.
1523	Aug. 14	China (Chehkiang), Tinghai and many neighbouring districts II H.
1524	Feb. 5	China, Pekin, Nankin ; (Honan, Shansi, Shensi) II H.
1524	Feb. 20	China (Kiangsu), Nankin, Suchou Fu, Changchou Fu I H.
1525	Sept. 8	China (Anhui), Fengyang Fu ; (Kiangsu), Hsuchou Fu ; (Honan), Huaiching Fu, Kaifeng Fu II H.
1525	Sept. 20	Japan, Kamakura, Aizu II O.
1526	May 22	China (Yunnan), Tengchung in Yungchang Fu ; (Kueichou), *Annanwei* II H.
1527	Mar. 25	Japan, Kioto I O.
1527	October	Italy, Pistoia in (Tuscany) II B.
1529	April	Italy (Udine) I B.

A.D.		
1529	July 3	Italy, Cremona I B.
1530	Sept. 1	Venezuela, coast of Paria and Cumana, Cubacua; the sea rose four fathoms and sank again II M.
1530	Nov. 11	Italy, Siena I B.
1531	Jan. 26	Spain and Portugal, Lisbon, 1,500 houses destroyed; the remainder of Portugal, Spain, the opposite coast of Africa, the Canton du Vaud in Switzerland, and Flanders; the sea was greatly agitated III M.
1531	Beginning of year	Switzerland, Bâle I M.
1536	Mar. 23	Italy, *Catania*, all Sicily II B.
1536	Aug. 10-11	Italy, Genoa II B.
1536	Oct. 22	China, Pekin and neighbouring districts I H.
1537	May	Italy, Catania, Corleone in (Palermo), Messina, Trapani II B.
1537	Sept. 26	Italy, Pozzuoli in (Naples) I B.
1537		Mexico, Valley of Mexico III O.B.
1537		Italy, Tuscany (1538 ?) I B.
1538		Ecuador, Antisana III R.S.
1538	Sept. 26-27	Italy, Pozzuoli and neighbourhood II B.
1540	April 8	Italy (Marches), Fermo I B.
1541	Oct. 22-23	Italy, Alessandria in (Milan) II B.
1542	Mar. 17	Mexico, Oaxaca II O.B.
1542	June 9 or 12 or 13	Turkey, Constantinople I M.
1542	June 13	Italy, *Mugello*, Florence, Pistoia and other towns in (Tuscany) III B.
1542	November	China (Shansi, Shensi and N. Kansu) I H.
1542	Dec. 10	Italy, Syracuse, Catania, felt in Palermo, Trapani, Sciacca III B.
1543		Chile, Tarapaca I Mon.
1544	January	Italy (Calabria) II B.
1544	May 23	Japan (Satsuma) II O.
1545		Japan (Satsuma) II Mi.
1515	June 9	Italy, *Borgotaro* and several places in (Parma and Piacenza) II B.
1546		In Palestine, Joppa, Sichem or Nablous, Rama; the sea retired several miles I M.
1546	June 2	Iceland, Southland, Olfus; many farms and some houses fell II Th.
1547	Feb. 10	Italy, *Reggio* in (Emilia), Modena I B.
1548		Italy, Catania in Sicily I B.
1549		Persia, Khorasan, Qayin; 3,000 killed III Ol.
1549		Italy (Calabria); Messina I B.
1549	Mar. 9	Japan, Kioto I O.
1549	May 3	Italy, Savona in (Milan) I B.
1549	May 21	Japan (Kai) II O.
1550	Feb. 28	Italy, Cuneo in (Piedmont) I B.
1550		Italy, Ariano, Vallo di Diano II B.
1551	Jan. 28	Portugal, Lisbon; 200 houses thrown down II M.
1552	Feb. 2	Iceland, Southland I Th.
1553	Aug. 17	Saxony, basin of the Elbe, principally at Meissen I M.
1553	Oct. 11	Japan, Kamakura II O.
1554	May 3	Iceland, strong shocks; no houses are said to have fallen; eruption of Hecla I Th.
1554	July 7	Greece, Zante III P.
1554	Nov. 28	Italy, Florence I B.
1555	Sept. 14	Japan, Aizu II O.
1556	Jan. 24	China (Shensi), *Weinan*, *Chaoyi*, *Sanyuan* in Hsian Fu, *Huachou* in Tungchou Fu; (Shansi), *Puchou Fu*; and (Honan). About 830,000 people were killed III H.
1556	Jan. 24	Bavaria, Austria in the "Windischmark," Hungary, Croatia, Dalmatia and Moravia III M.
1556	Mar. 22	Japan, Kioto I Mi.
1556	April 20	Italy, Bolena in (Nice) II B.
1556	May 10	Turkey, Constantinople I M.
1556	Nov. 17 ?	Italy, Rossano in (Cosenza) II B.
1557		Italy, Campagnano in (Ischia) I B.
1557	July 5	Japan, Kioto I Mi.

A.D.		
1558	April 13	Italy, *Siena*, Florence and throughout (Tuscany) I B.
1558	April	Mexico, throughout the country III O.B.
1558	Nov. 24	China (Shensi), Huachou in Tungchou Fu II H.
1560	May 11	Italy, Barletta, Bisceglie in (Apulia) II B.
1561	Feb. 21	China (Kansu), Shantan in Kanchou Fu II H.
1561	Mar. 2	Argentina, Mendoza I Mon.
1561	July-Aug.	Italy, *Buccino* in (Salerno) and throughout the (Terra de Lavoro, Principato-Citra and the Basilicata) III B.
1561	Aug. 5	China (Shansi), Taiyuan Fu, Tatung Fu ; (Shensi), Yulin Fu ; (Kansu), *Ninghsia Fu* and *Kuyuan* in Pingling Fu III H.
1561	Nov. 24	Italy, Ferrara II B.
1561		Italy, Ravenna I B.
1562	Feb. 14	China (Kansu), Ninghsia Fu ; Pekin II H.
1562	Oct. 28	Chile, Santiago, Arauco, sea waves III Mon. & P.
1563	Feb. 28	Japan (Hitachi, Iwaki, Shimotsuke) ; Aizu III O.
1563	Dec. 27	Japan (Hitachi, Musashi, Iwaki, Shimotsuke) ; and Aizu III O.
1564		West Indies, Hayti, Conception de la Vega III O.D.
1564	April 27	Japan, Kioto I O.
1564	July	France, at Nice and in Provence II M.
1564	July 20-Aug. 5	Italy, *Bollena*, *Rocchia*, Roccabigliera and other places in the valley of Vesubia and neighbourhood in (Nice) III B.
1565		France, neighbourhood of Nice I M.
1566	Jan. 22	China (Fukien), Fuchou Fu, Hsinghua Fu, Chuachou Fu I H.
1566	Nov. 30	Italy, Randazzo, Messina I B.
1567	Aug. 27	Italy, Norcia in (Perugia) I B.
1567	Dec. 30	Mexico (Mexico) and Chapala in (Jalisco) II O.B.
1568	April 1	China (Kansu), Chingyang Fu, Huan, Ninghsia Fu ; (Shensi), Changhan ; (Shansi), Anyi and Puchou Fu ; (Hupeh) Yunyang ; (Honan) III H.
1568	April 25	China (Chihli), Pekin, *Leting*, Yungping Fu ; (Shantung), Tengchou ; also at (Ssuchuan), Shunching ; Castle of Ningyuen was destroyed III H.
1568	April 30	China (Honan), Huaiching Fu, Nayang Fu, Juning Fu ; (Kansu), Ninghsia II H.
1568	May 2	China (Shensi), Fenghsiang Fu, Hsian Fu ; (Kansu), Pingling Fu, Chingyang Fu II H.
1568	Dec. 27	Mexico, Cocula and *Tzacoalco* in (Jalisco) II O.B.
1570	Feb. 8	Chile, Concepcion, with sea waves III Mon.
1570	June 17	Italy, Pozzuoli in (Naples) I B.
1570	Nov. 17	Italy, *Ferrara*, Treviso, Padua, Bologna and Venice II B.
1572	Jan. 28	Tyrol and Germany, Innsbruck, Munich and Augsburg I M.
1572	Mar. 14	Japan, Nara I O.
1572	June 4	Italy, Parma I B.
1572	July 13	Italy, Cartoceto in (Pesaro) II B.
1572	July 20	Japan, Nara, Kioto I O.
1572	Dec. 21	Switzerland, the whole of the canton of Glarus I M.
1573	Nov. 14	Mexico, *Colima*, Guadalajara ; (Michoacan) ; Oaxaca II O.B.
1574		Baden or Transylvania ? Offenburg I M.
1574		England, Tewkesbury I M. & W.
1574	Mar. 11	China (Fukien), Changting in Tingchou Fu II H.
1575	February	China (Hunan, Hupeh, Kiangsi) I H.
1575	Mar. 17	Chile, Santiago, Valdivia III Mon. & P.
1575	June 5	Italy, Naples ? I B.
1575	June 9	China (Hupeh), Hsiangyang Fu, Yunyang Fu ; (Honan), Nanyang I H.
1575	July 28	China (Fukien), Fuchou Fu, Tingchou Fu, Changchou Fu ; (Kuangtung), Chaochou Fu I H.
1575	Nov. 17	China (Kansu), Kungchang Fu II H.
1575	Dec. 16	Chile, Santiago, as far as Castro III Mon.
1575		Mexico, Zacateotlan and Acatzinco (Puebla) I O.B.
1577	Mar. 12 & 13	China (Yunnan), Yungchang Fu III H.
1578		Italy, Sciacca in (Girgenti) II B.

A.D.		
1578	June 17	Peru, Lima II H.J.
1578	Nov. 1	Iceland, Southland, Olfus; many farms fell II Th.
1578	Dec. 8	Japan (Mikawa) II O.
1579	Dec. 19	Japan, Nara I O.
1580		West Indies, Cuba, Santiago III O.D.
1580	April 6	England, London, Dover I M. & W.
1580	June 25	China (Chihli), Tsunhua II H.
1580	Sept. 6	China (Shansi), Chingping, Pinglu, Pingyang Fu II H.
1581	May 18	China (Chihli), Yuchou in Hsuanhua Fu; (Shansi), Tatung Fu I H.
1581	May	Iceland, Rangarvellir and Hvolhreppr III Th.
1582	Jan. 16	Peru, Arequipa III Mon.
1582	Jan. 22	Peru, Arequipa *also* at Lima III H.J., M. See Jan. 16.
1582	May	Italy, Pozzuoli and Naples I B.
1582	July 2	Peru, Arequipa III H.J.
1582	Sept. 16	Japan, Nara I O.
1583	Feb. 10	Japan, Nara I O.
1583	Oct. 11	Mexico, throughout the country III O.B.
1584	Mar. 1	Italy, Savoy, Valais in Switzerland I B.
1584		Iceland, South Country II Th.
1584	Sept. 10	Italy, San Piero in Bagno (Romagna) II B.
1584	Mar. 1	Throughout Switzerland, Burgundy, Dauphiny, Piedmont, and Greifensee I M.
1584	June 17	Armenia, Erzingan III M. & O.
1585	Feb. 7	China (Kiangsu), Huaian Fu, Yangchou, Chiangning Fu; (Anhui), Louchou Fu I H.
1585	April 6	China (Shansi), Tatung Fu I H.
1585	July 31	Japan (Mikawa, Yamato) II O.
1586	Jan. 8	Japan, Kioto and Central Japan III Mi.
1586	July 9	Peru, Lima III H.J.
1586		Guatemala III M.
1587	Aug. 30	Ecuador, Quito III R.S.
1588	Oct. 7	Italy, Dronero in (Cuneo) I B.
1589	Mar. 17	Japan (Suruga, Totomi) III Mi.
1590	Sept. 15	Central Europe, Austria, especially at Vienna, Maurach, Tuln, Hungary, Moravia, Glatz in Silesia, Bohemia, Saxony and the Alps III M. & Ra.
1590	July 7	China (Kansu), Kanchou and Lintao III H.
1590		Peru, Cumana III H.J.
1590		Chile III P.
1591	July 10	Italy, *Vicenza* (Romagna), Forli, Venice I B.
1591	July 26	Azores, *St. Michel;* sea waves. II M.
1591	Nov 21	China (Kansu), Shantanwei II H.
1592	May	Greece, Zante III P.
1592	Oct. 8	Japan, Tokio I O.
1592	Nov. 24	Italy, Trevi in (Perugia) I B.
1593	Mar. 8-9	Italy, Bergamo in (Lombardy) I B.
1593	April 24	Italy, Corleone in (Palermo) II B.
1595	Aug. 17	Japan, Kioto (Yamashiro, Yamato, Omi, Tamba, Kawachi, Settsu) I Mi.
1596	Aug. 5	Japan, Kioto, Osaka; (Satsuma) III Mi.
1596	Sept. 4	Japan, Kioto, Kinai; (Kii, Chikuzen) III O.
1596		England (Kent) I M. & W.
1596		Russia, *Nizhni-Novgorod* III M. & O.
1597	Jan. 3	Iceland, Skalholt; many farms fell II Th.
1597	Spring	Iceland, Olfus, with eruption of Hecla II Th.
1597	July 28	Portugal, Lisbon II M.
1597	Aug. 3-4	Italy, Scarperia in (Florence) II B.
1597	Oct. 2	China (Shingking), Liaoyang and Kuangning II H.
1598	Feb. 7	China (Hupeh), Changle in Yichang II H.
1598		Asia Minor, *Amasia* and *Chorum* III M. & O.
1599	June 25	24th, 17h. 20m., G.M.T Philippines, ***Manila***, Southern Luzon III S.M.
1599	Sept. 18	China (Hupeh), Anlu Fu, Mienyang; (Hunan), Yochou Fu I H.
1599		Italy, Reggio in (Calabria), Messina and surrounding country I B.
1599-1600		Italy, Cascia in (Perugia) I B.
1600	Jan. 2	Philippines, Manila II S.M.
1600	July 5-6	Italy, Florence I B.

A.D.		
1600	July 28	Japan, Tsugaru, with eruption of Iwakiyama III O.
1600	Sept.	Italy, Issime in (Aosta) II B.
1600	Nov.	Philippines, Manila I S.M.
1601	Jan. 16	Philippines, Manila II S.M.
1601	Sept. 8	Throughout almost all Europe, especially in Germany and part of Asia; most violent in Switzerland, Austria, Bohemia, Bavaria, Swabia, Alsace and part of the Netherlands I M.
1603	May 30	China (Hupeh), Chunghsiang in Anlu Fu II H.
1603	June 7	Japan, Tokio I O.
1603		Mexico (Oaxaca), especially *Mixteca* III O.B.
1604		Italy, Perugia I B.
1604	Jan. 22-23	Japan, Kioto I O.
1604	March	Mexico, Oaxaca town III O.B.
1604	Aug. 12	Japan, Kioto I O.
1604	Oct. 25	China (Kansu), Kungchang Fu; (Shensi), Lichaun, Hsian Fu; (Kiangsi), Paiyang in Kuanghsin Fu; (Kiangsu), Wu in Suchou Fu. Possibly two earthquakes III H.
1604	Nov. 23	Peru, Arequipa III H.J. See Nov. 24
1604	Nov. 24	Chile and Peru, Arica to Arequipa III Mon. See Nov. 23
1604	December	Chile, La Serena I Mon.
1605	Jan. 31	Japan, Kiushu, Shikoku, Central Japan: with sea waves III Mi.
1605	July 14	China (Kuangsi), Luchuan in Yulin III H.
1606	Aug. 22	Italy, Bergamo I B.
1607	Feb. 2 & 16	Japan, Tokio I O.
1607	Sept. 16	China (Ssuchuan), Lungan Fu, Mou I H.
1608	Jan. 8	Mexico (Oaxaca) III O.B.
1608	Dec. 3	Philippines, Leyte Island, Dulag and Palo II S.M.
1609	July 13	China (Kansu), Kanchou Fu, more than 840 lives lost; (Chehkiang), Tungkuan in Shaohsing Fu, the land opened for a length of 870 li, about 310 miles III H.
1609	July 20	Italy, Nicastro in (Catanzaro) II B.
1609	Oct. 19	Peru, Lima II H.J.
1610	Nov. 29	Switzerland, Bale I M.
1610	Nov.	Philippines, East Luzon, along the Eastern Range Sierra Madre III S.M.
1611	Jan. 15	Italy, Val di Luserna in (Piedmont) I B.
1611	Aug. 25-31	Mexico, Mexico City and (Jalisco) III O.B.
1611	Sept. 8	Italy, *Scarperia*, Mugello and Florence II B.
1611	Sept. 27	Japan, Aizu II O.
1611	Dec. 2	Japan, Sendai, Yezo, with sea waves III O.
1611	Dec. 9	Persia, Khorasan, Dughabad III Ol.
1612	Jan. 31	Italy, *Roccabigliera*, Loano and other places in (West Liguria) II B.
1612	Mar. 12	China (Yunnan), Tali Fu, Wuting Fu, Chuching Fu, Yunnan Fu; also in Burma III H.
1612	July 2	China (Yunnan), Yunnan Fu and Chuching Fu III H.
1612	Nov. 8-Dec. 7	Germany, Westphalia, especially at Bielefeld and the Castle of Sparenberg; also the Island of *Candia* and several places in the Mediterranean: much destruction III M.
1613	Aug. 25	Italy, Naso in Messina III B.
1613	Spring	Iceland, South Country, Skeid; farms fell II Th.
1614	May 4	Azores, Island of Terceira, Angra, Praya II M.
1614	Oct. 24	China (Shansi, Honan) II H.
1614	Nov. 28	Japan, Kioto; (Echigo); sea waves III Mi.
1615	Mar. 1	China (Kiangsu), Yangchou Fu: (Hupeh), Langchan, now Changyang, in Yichang Fu II H.
1615	June 26	Japan, Tokio III O.
1615	Sept. 16	Chile, Arica III Mon.
1616	March	Different parts of Switzerland II M.
1616	Sept. 9	Japan, Sendai II O.
1617	Jan. 14	Italy, Lantosca and other places in (Nice) II B.
1617	July 5	Germany, Freiburg in the Breisgau I M.
1618	Jan. 18	Italy, Saorgio and elsewhere in (Nice) I B.
1618	May 26	India, Bombay, earthquake? III Ol.

A.D.		
1618	Aug. 25	Throughout Switzerland, in the Pays du Vaud, Grisons and the Valteline III M.
1618	Nov. 17	China, Pekin; (Shansi), Ningwu Fu, and seventeen other districts II H.
1619	Jan. 5	Italy (Calabria) I B.
1619	Feb. 13	Mexico, Oaxaca and throughout most of the country III O.B.
1619	Feb. 16	Peru, Trujillo III H.J.
1619	Autumn	Iceland, Tengeyjarsysla (Northland) I Th.
1619	Nov. 27	Persia, Khorasan, Dughabad III Ol.
1620		Philippines, Panay Island, *Iloilo, Capiz* III S.M.
1620	Mar. 5	China (Yunnan), Yunnan Fu; (Kuangtung), Chaoching Fu, Huichou Fu; (Hupeh), Chingchou Fu, Chengtan Fu II H.
1621	May 20	Switzerland, at Bâle and Neufchâtel, in the Canton du Vaud, at Geneva and in Savoy I M.
1622	Mar. 18	China (Shantung), Tungchang Fu; (Honan) III H.
1622	April 17	China (Shantung), Tungchang, and eight other districts III H.
1622	May 6	Mexico, Zacatacas III O.B.
1622	June 7	Mexico, Oaxaca town II O.B.
1622	Sept.	Mexico, Zacatacas III O.B.
1622	Oct. 25	China (Kansu), Langte and neighbouring districts in Pingliang; about 11,800 houses were damaged and 12,000 people killed or wounded III H.
1622	Nov. 18	Japan, Kioto I O.
1624	Feb. 10	China (Kiangsu), Nankin and six other districts, *Yangchou Fu* II H.
1624	Mar. 21	Italy, Argenta in Ferrara II B.
1624	Mar. 31	China (Chihli), Shuntien Fu, Yungping Fu II H.
1624	April 17-23	China (Chihli), Leting in Tungping Fu II H.
1624	June 19	Japan (Shimotsuke) II O.
1624	July 20	China (Chihli), Paoting Fu II H.
1624	October	West Indies, Cuba, Santiago III O.D.
1624	Oct. 3-5	Italy, Mineo in Catania II B.
1624	Nov. 9	Japan, Kioto I O.
1624	Nov. 11	Iceland, Southland; many farms fell in Floi II Th.
1625		Italy, Termoli in (Campobasso) I B.
1625	Dec. 5-6	Italy, Rimini and environs I B.
1625		Colombia, Bogota, Caracas I O.D.
1626	March-April	Italy, Girifalco in (Catanzaro) II B.
1626	May 12	Italy, Macerata in the (Marches) I B.
1626	June 28	China (Chihli), Taming and Kuangping; (Shantung), Tungchang Fu; (Honan), Honan Fu; (Shansi), Pingyang III H.
1627	Feb. 5 to Mar. 18	China (Kansu), Ninghsia III H.
1627	Feb. 26	Japan, Kioto I Mi.
1627	Mar. 8	Japan, Tokio I O.
1627	July	Italy, Accumoli in (Aquila) II B.
1627	July 30	Italy, Region of Garganica in (Apulia), especially *San Severo, Serra Capriola, San Nicandro* III B.
1627	August	Philippines, N. Luzon (Cagayan, Ilocos Norte), Aparri, *Lavag* III S.M.
1628	Aug. 10	Japan, Tokio II Mi.
1628	Oct. 3-4	Italy, Parma I B.
1628		Philippines, S.E. Luzon (Ambos Camarines and Albay), *Camalig, Albay*, Nueva Caceres III S.M.
1628	Dec.	Germany, in the Duchy of Mecklenburg I M.
1630	Feb. 21	Iceland, South country, Skalholt II Th.
1630		Arabia, Mecca, Medina ? II M.
1630	Aug. 1	Japan, Tokio II O.
1630	Nov. 27	Peru, Lima II H.J.
1631	Jan. 27	Japan, Tokio I O.
1631	July 22	China (Kansu), Lintao and Kungchang III H.
1631	Dec.	Italy, *Torre del Greco* and Naples, preceding an eruption of Vesuvius I B.
1632		Argentina, Esteco in (Salta) I Mon.
1632	June 17	China, Nankin also (Ssuchuan) I H.

A.D.		
1633	Feb. 21-22	Italy, Nicolosi in (Catania), preceding an eruption of Etna II B.
1633	Feb. 5 to July 17	Mexico (Oaxaca), Puebla and Vera Cruz; extended from the coast of Ecuador to Canada III O.B.
1633	Feb. 28	Japan Odawara III Mi.
1633	May. 14	S. Chile, Carelmapu I Mon. & P.
1633		Iceland, Southland; farms fell in Olfus II Th.
1634-5		Italy, Tregastagne, at foot of Etna and Messina, during eruption of Etna II B.
1634	Nov. 10	Italy, Matera in the (Basilicata) I B.
1635	Mar. 1	Japan, Tokio II O.
1635	Mar. 10	Japan, Matsumai, Yezo III O.
1635	Mar. 12	Japan, Tokio II O.
1636	Sept. 1	Malta II O.D.
1636	Sept. 30	Greece, Island of Zante II M. & P.
1636	Dec. 21	Philippines, S.W. Mindanao (Cotobato and Lanao), district around *Illana Bay*, Cotobato, Polloc III S.M.
1638	January	China (Shensi), Hsian Fu II H.
1638	Mar. 27	Italy, throughout (Calabria), especially destructive from Oppido to beyond Bisignano, also in Zante III B. & P.
1638	June 2	U.S.A., New England II M.
1638	Oct. 6	Italy, Parma I B.
1638	Oct. 10	China (Shingking), Liaotung I H.
1638		England, Chichester I B.
1638		Iceland, South country, Olfus II Th.
1639	Mar. 12	Japan, Tokio II O.
1639	Oct. 7-8	Italy, Amatrice and neighbouring towns in (Aquila) III B.
1639	Nov.	Japan (Echigo) II O.
1640		Persia, Tabriz and Damascus II M.
1640	June 19	Italy, Badolato in (Catanzaro) II B.
1641	Jan. 4	Philippines, N. Luzon (Ilocos Norte), North part of (Mountain and Cagayan), *Aparri*, Laoag III S.M.
1641		Venezuela, Caraccas I P.
1641	Feb. 5	Persia, Tabriz; also felt at Bagdad III M. also M. & O.
1641	June 8-10	Italy, Pontoremoli and throughout the Lunigiana in (Tuscany) I B.
1642	June 13	Italy (Lombardy), Bergamo, Milan, Lecco and Parma I B.
1643	July 17	Italy, Troina in (Catania) I B.
1643	Sept. 6	Chile, Santiago I Mon.
1643	Nov. 11	China (Anhui), Fengyung I H.
1644	Jan. 12	China (Anhui), Hochiu, Mengcheng, Ying in Yingchou Fu I Ho.
1644	Jan. 15	China (Kiangsu), Hsiao, Feng, Pei, Suchien in Hsuchou Fu I Ho.
1644	Jan. 16	5.30 a.m. Columbia, Pamplona III O.D.
1644	Feb. 15	Italy and France, Belvedere, Bollena, Roccabigliera, Lantosca in (Nice), Aix and Marseilles II B.
1644	Mar. 4	China (Kiangsu), Chiangning Fu; (Kiangsi), Yuanchou, Wantsai, Fengi in Yuanchou Fu I Ho.
1644	March	Japan, Nikko II O.
1644	Oct. 18	Japan (Ugo) II O.
1645		Chile II P.
1645	Nov. 30	12h. 0m. G.M.T. Philippines: all Luzon except Ambos Camarines and Albay III S.M.
1645	Dec. 5	15h. G.M.T. Philippines, same district as Nov. 30 II S.M.
1645		Austria, Croatia, Karlstadt I F.
1646	March	Philippines, S. Luzon, Manila and neighbouring provinces I S.M.
1646	April 5	Italy, Leghorn I B.
1646	April 28	Italy, Aquila in (Abruzzi) I B.
1646	May 31	Italy, Ischitella, Gargano and other towns in (Foggia) III B.
1646	June 9	Japan, Sendai; (Uzen, Ugo, Rikuchu, Mutsu) III O.
1646	Dec. 21	Japan, Kioto I O.
1646		Austria, Croatia, Karlstadt I F.
1647	May 13	Chile, Santiago, Concepcion, felt from Poz de Maulo to Chuapa III P., H.J. & Mon.

A.D.		
1647	June 15	Japan, Tokio ; (Sagami) II Mi.
1648		Austria, Dalmatia, Zeng I M.
1648	April 2	Armenia, Van III M. & O.
1648	June 13	Japan, Hakone, Tokio, Kioto III Mi.
1648		Philippines, Central Luzon II S.M.
1649	January	Italy, Messina and felt at Reggio I B.
1649	Mar. 17	Japan (Yamashiro, Aki, Iyo) III Mi.
1649	July 29	Japan, Tokio, Nikko III Mi.
1649	Sept. 1	Japan, Tokio II O.
1649	Nov. 10	China, Pekin I Pa.
1650	Jan. 26	China (Fukien), Langyen circuit III Ho.
1650	Beginning of March	Greece, Island of Santorin I M.
1650	Mar. 31	Peru, Cuzco, Lima III H.J.
1650	April 23	Japan (Sagami, Musashi, Awa, Kadsusa, Shimosa, Hitachi, Kotsuke, Shimotsuke) I Mi.
1650	Nov. 4-10	Bolivia, La Plaz II Mon.
1651	Jan. 14	China (Fukien), Yenping Fu, *Tingchou Fu*, Shaowu Fu III Ho.
1651		England (Cumberland and Westmoreland) I M. & W.
1651		Peru and Chile III P.
1652	Feb. 18	China, Pekin I Pa.
1652	Mar. 23	China (Anhui), Ssuchou, Taihu in Anching Fu, Chihchou Fu II Ho.
1652	Mar. to April	China (Kiangsi), Jaochou Fu ; (Hupeh), Hayang Fu, Hsiangyang Fu I Ho.
1652	April to May	China (Anhui), Luchou Fu ; (Kiangsi), Hukou in Chiuchiang Fu, Nanan Fu I Ho.
1653		China (Shensi), *Luchyang* in Hanchung Fu, *Yenan Fu* III Ho.
1653	May 1	Philippines, Manila and neighbouring provinces I S.M.
1653	Sept. 27	Italy, Cesena, Faenza in (Emilia) I B.
1653		Asia Minor, Smyrna ; 2,000 to 3,000 killed III M.
1654	Feb. 7 to 21	China (Anhui), Chihchou Fu, Tungliu, Luchiang in Luchou Fu II Ho.
1654	June 20-22	China (Shensi), *Hsian Fu*, Hanchung Fu III Ho.
1654	July 21 to August	China (Shensi), Hsian Fu, Yenan Fu, Hanchung Fu, *Fenghsiang Fu ;* (Kansu), Pingliang Fu II Pa.
1654	July-Aug.	China (Kuangtung), Shunte, Hsiangshan, Tsengcheng, Hsinhui in Kuangchou Fu II Ho.
1654	July 23	Italy, *Sora*, Arpino, Casalvieri and other towns in the Terra di Lavoro III B.
1654	Sept. 8	Italy, Atella in (Basilicata) II B.
1655	Jan. 21	Formosa, Tainan III H.
1655	Mar. 25	Italy, Rocca S. Casciano in (Florence) I B.
1655	Sept. 4	China (Shantung), Yenchou Fu, Tsaochou Fu I Ho.
1655	Nov. 13	Peru, Lima III H.J. M. gives I
1656		Syria, Tripoli II M.
1656	Oct. 17	Italy, S. Severo in (Foggia) I B.
1657	Feb. 15	France, St. Maure, not far from Tours and the environs for six miles round II M.
1657	Mar. 15	Chile, Santiago, Concepcion ; with sea waves III Mon. & P.
1657	Mar. 16	Iceland, South and Westland, Floi, Fliotshlid III Th.
1657	May 3	China (Ssuchuan), Paoning Fu II Pa.
1658		Greece, Island of Cephalonia II M.
1658	Feb. 3	China (Chihli), Hsinchong in Paoting Fu, Yichou, Nanpi, Yenshan in Tiensing Fu II Ho.
1658	Feb. 14	Peru, Trujillo III H.J.
1658	Feb.-Mar.	Malta I B.
1658	May 5-15	China (Kiangsu), Tungtai in Yangchou Fu II Ho.
1658	Aug. 20	9hr. 0m. G.M.T. Philippines, S. Luzon, Manila and neighbouring provinces III S.M.
1658	Sept. 20	China (Kiangsu), Hsinyang in Suchou Fu, Chihchou Fu, Shanghai, Taitsangchou II Ho.
1659	April 21	Japan (Shimotsuke, Mutsu) III O.
1659	Nov. 10	Italy, *Catanzaro* in (Calabria) III B.
1659		Turkey, Constantinople II M.
1659	Dec. 25	China (Fukien), Yenping Fu, Ninghua in Tingchou Fu I Ho.

A.D.		
1660		Italy, Modena I B.
1660		Greece, Cephalonia I P.
1660	June 8	China (Honan), *Nanyang Fu* III Ho.
1660		Formosa, Tainan III H.
1661	Jan. 8 or 9	Switzerland, throughout the Canton of Glarus I M.
1661	Jan. 8 or 9	Formosa ; the sea was violently agitated II M.
1661	Mar. 12	Italy, Bergamo in (Lombardy) II B.
1661	Mar. 22	Italy, *Galeata*, Rocca S. Casciano, S. Sofia and other towns in Romagna III B.
1661	July	Italy, Otranto in (Lecce) II B.
1661	Aug. 4	Japan (Higo) I O.
1661	Dec. 10	Japan (Tosa) II O.
1662	Jan. 26	U.S.A., New England I M.
1662	May 12	Japan, Kioto (Yamashiro, Kawachi, Settsu) II Mi.
1662	June 16	Japan, Kioto ; (Omi, Hizen, Shinano) III Mi.
1662	Oct. 30	Japan (Hyuga, Osumi) III Mi.
1662	Nov. 23	Ecuador, Quito III R.S.
1662		Crete I P.
1663	Jan. 5	Canada, St. Lawrence Valley, Quebec, Sillery, Tadoussac I M. & O.D.
1663	Feb. 5	U.S.A., New England States. 3 violent shocks I F.R.
1663	Mar. 4-13	China (Hupeh), *Anlu Fu* III Ho.
1663		Iceland, Reykjanes peninsula; many farms abandoned II Th.
1663	Aug. 27	Japan, Yezo, Matsumai III Mi.
1664	Jan. 4	Japan, Kioto II Mi.
1664		Persia, Tabriz and the country round I M.
1664	Mar. 24	Greece, Zante I P.
1664	May 12	Peru, Ica II H.J.
1664	Aug. 3	Japan (Kii) III O.
1664		Japan, Torishima (Loochoo) III O. Same as above ?
1664		India, near Dacca I Ol.
1665	January	Island of Candia II M.
1665	April-May	China (Honan), Chiachou ; (Chihli), Shuntien Fu, Paoting Fu, Chichou II Ho.
1665	June 12	Japan, Tokio I O.
1665	June 19	Philippines, S. Luzon, Manila and neighbouring provinces II S.M.
1665	June 25	Japan, Kioto III O.
1666	Jan. 19	England, Coventry I R.
1666	Feb. 11	Japan (Echigo), Takata II Mi.
1666	April 14	Italy, Bologna I B.
1666	Nov.	Assyria, *Mensal*, Mosul ? and the country round, five towns and 45 villages ruined III M.
1667		West Indies, Jamaica II P.
1667		Italy, Spoleto in (Perugia) and other towns I B.
1667	Jan. 2	China (Kiangsu), Suchou Fu, Taitsangchou I Ho.
1667	April 6	Austria, Ragusa, Dalmatia I B.
1667	July 30	Mexico, Mexico City ; (Puebla) I O.B.
1667	Nov.	Caucasia, *Shemaka* ; 80,000 persons perished III M.
1668	May	India, Samawani or Samaji, Delta of Indus III Ol.
1668	June 9	China (Honan), *Shangcheng* in Kuangchou III Ho.
1668	June 14-18	China (Chihli), Shuntien Fu I Ho.
1668	July 3 to Sept. 13	Asia Minor, Angora, Caesarea (Kaisarije), Coniyeh I M.
1668	July 4 to Aug.	All Eastern China (*Shantung*) III Ho.
1668	Aug. 27	Austria, Neustadt I M.
1668	Aug. 28	Japan, Sendai III O.
1668		West Indies, St. Christopher I M.
1669	January	Caucasia, Shemaka and Lajka III M. & O.
1669	Mar. 11	Italy, Nicolosi in (Catania) II B.
1669	June 4	Upper India, near Fort Mandraian II Ol.
1669	June 22	India, Cashmir I Ol.
1669	June 23	India, Atock II Ol.
1669	Sept. 6	Japan, *Tokio* I O.
1670	Jan. 17	Italy, *Hall* and Innsbruck in the Tyrol, and the adjacent country, south to Venice, north to Wildungen, Augsburg, Donauworth, and Nuremberg, west to the Lake of Constance and the Canton of Glarus II M.
1670	Jan. 22	Caucasia, Shemaka II M. & O.

A.D.		
1670	July 21	Japan (Sagami) III O.
1670	Sept. 28	Japan (Tsushima) III O.
1670		Caucasia, Shemaka II M. & O.
1670	Dec. 22 & 23	Caucasia, Shemaka III M. & O.
1671	Jan. 1	Caucasia, Shemaka II M.
1671	Feb. 1	Caucasia, Shemaka II M.
1671	June 20	Italy, *Modena*, Reggio in (Emilia), Verona III B.
1671	Summer	Iceland, Grimsnes and Olfus; many houses fell III Th.
1671	Aug. 8	Caucasia, Shemaka II M.
1671	Sept. to Oct.	China (Shantung), Yenchou Fu, Yichou Fu, Anchiu in Chingchou Fu; (Kiangsu), Hsiao in Hsuchou Fu II Ho.
1672	April 14	Italy, *Rimini*, Castelnuovo, Fano and other towns in the (Marches) III B.
1672	June 8	Italy, Amatrice, Montereale in (Aquila) II B.
1672	Oct. 10-12	China (Kiangsu), Paoshan, Ciating in Taitsangchou, Suchou Fu I Ho.
1672	Dec. 5	China (Fukien), Lienchiang in Fuchou Fu III Ho.
1672		Most of the Grecian Islands, especially Santorin & Stanichio II M.
1673	Aug.	Persia in (Khorasan), *Meshed*, *Nishapur* II M.
1673	Oct. 8	China (Chihli), Huairu in Hsuanhua Fu III Ho.
1673	Oct. 18	China (Chihli), Shuntien Fu, Yichou, Yungping Fu I Ho.
1675	Feb.	Philippines, S. Luzon (Mindoro, Batangas), Taal, Calapan II S.M.
1675	Feb. 11	West Indies, Cuba, Santiago III O.D.
1676	June 17	Italy, Ivrea (Piedmont) II B.
1676	July 12	Japan (Iwami) III O.
1676	July	China (Chihli), Pekin, Tungchou, comprising Tung, Tsunhua and Yungping III H.
1677		West Indies, Jamaica, Port Royal II P.
1677	April 13	Japan, Tsugaru, Nambu III O.
1678	April 5	China (Honan), Yushih, Weichuan in Kaifeng Fu; (Shansi), Tungliu, Luan Fu I Ho.
1678	April 22	France, Blois I M.
1678	May 24	China (Kiangsu), Taitsangchou, Sungchiang Fu I Ho.
1678	Oct. 2	Japan, Tokio I O.
1679	Feb. 11	West Indies, Cuba, Santiago II O.D.
1679	June 4 to 12	Caucasia, the fort of Erivan and all the country round, to the Ararat chain III M., M. & O.
1679	Aug. to Sept.	China (Shensi), *Yenan Fu*; (Honan, Chihli) II Ho.
1679	Sept. 2 to 7	China, *Pekin*: (Shantung, Honan, Kiangsu) III Ho.
1679	Oct. 9	Throughout the whole of Spain, principally in the kingdom of (Grenada), *Malaga* II M.
1681	Jan. 27	Switzerland, Canton of (Glarus) and *Appenzel* I M.
1681	Mar. 10	Chile, Arica I Mon.
1682		West Indies, Santiago de Cuba I O.D.
1682	Mar. 19	Mexico, Mexico City and *Oaxaca* II O.B.
1682	May 2	France, throughout the whole of Savoy, Provence, Alsace, Burgundy, and as far north as Paris, and in Thuringia in Germany, Switzerland, *Bâle*, *Neuchâtel*, *Geneva*, and Glarus I M.
1683	Whit-Monday	Austria, Styria, Mariazell I Ra.
1683	May 1	Japan, Nikko I O.
1683	June 18	Japan, Tokio; Nikko (Shimotsuke) II Mi.
1683	Aug. 21	Philippines, Manila II S.M.
1683	Oct. 20	Japan, Nikko, Tokio II Mi.
1683	Nov. 22	China (Honan), Yushih in Kaifeng Fu; (Chihli), Kuangchang in Yichou, Tungkuang in Hochien Fu I Ho.
1683	Nov. 27	Caucasia, Erivan and on the frontiers of Persia and Turkey I M.
1684	Feb. 26	Different parts of Switzerland, especially in the Haut-Valais, and perhaps at Lausanne and Bâle I M.
1685	Oct. 8	Japan (Suwo, Nagato) II O.
1686	May 12	Formosa III Ho.
1686	June 10	Formosa I H.
1686	Oct. 3	Japan (Totomi, Mikawa) II Mi.
1686		Chile, with sea waves III P.
1687	Feb.	Philippines, Manila and neighbouring provinces I S.M.

A.D.		
1687	April	Persia, the town of Machat on the borders of India was ruined II M. Makat is in Chinese Turkestan.
1687	April 25-26	Italy, Amalfi in (Salerno) I B.
1687	Oct. 2	Italy, Tropea in (Catanzaro) II B.
1687	Oct. 20	Peru, Lima, *Callao*, and an immense district along the sea coast of Peru; sea waves. III M. Mon. gives Oct. 21.
1688		West Indies, Jamaica, Port Royal II O.D.
1688	January	Italy, Pisticci in (Basilicata) II B.
1688	Mar. 1	West Indies, Jamaica, Port Royal II M. M.H. gives Feb. 19.
1688	April 11	Italy, *Colignola*, Bagnacavallo and other towns in Romagna III B.
1688	May 31-June 1	Italy, Fano in (Marches) II B.
1688	June 5	Italy, *Benevento* (Avellino), Salerno, Campobasso (Foggia, Lecce and Basilicata) III B.
1688	July 10	Asia Minor, Smyrna: 15,000 to 20,000 killed III M.
1688	July 12	Chile, Santiago I Mon.
1688	July 23	Italy, S. Severo, Torremaggiore and elsewhere in Apulia and Calabria I B.
1688	Oct. 4	China (Yunnan), Hohking and Kienchuan III Pa.
1689		England, Lyme Regis (Dorset) I R.
1689	Sept. 21	Italy, Bari and neighbourhood I B.
1690	April	West Indies, Antigua, Barbadoes, St. Christopher III O.D. & P.
1690	July 9	Chile, Santiago I Mon.
1690	Dec. 4	Italy (Venetia, Istria); Laibach and *Villach* in Austria II B. & Ra.
1690	Dec. 22-23	Italy, *Ancona*, Sirdo and other places in the neighbourhood II B.
1691		West Indies, Hayti, the town of Azua in St. Domingo II M.
1692	June 7	West Indies, Jamaica, Port Royal, 3,000 persons perished III M.
1692	Sept. 13	Argentina, Tucuman, Esteco I Mon.
1692	Oct. 24	Italy, Fano in (Marches) II B.
1692		England, London I M. & W.
1693	Jan. 11	Italy (Catania), and other towns in the province and in (Syracuse) III B.
1693	Feb. 13	Iceland, Southlandunderland, also eruption of Hecla I Th.
1693	June 11	Malta III O.D.
1693	July 6	Italy, *Mantova*, *Goito*, Ferrara, Venice II B.
1693		West Indies, Cuba, Havana; 1,500 houses thrown down III M.
1694	April 8	Italy, S. Sepolcro in (Arezzo) I B.
1694	June 19	Japan (Ugo), Aikta III Mi.
1694	Sept. 8	Italy (Avellino and Basilicata) III B.
1695	Feb. 25	Italy, *Asolo* in (Treviso) and elsewhere in (Venetia, Lombardy and Emilia) II B.
1695	May	Japan, Higo II O.
1695	May-June	China (Shensi, Kansu, Shansi, Chihli) II Ho.
1695	May 18	China (Shensi, Honan, Hupeh) II Ho.
1695	June 11	Italy, *Bagnorea* and neighbouring towns (Latium) III B.
1696	June-July	China (Yunnan), Linan Fu I Ho.
1696	Aug. 23	Mexico, *Oaxaca*; *Orizaba* in (Vera Cruz) and generally in the E. and S. III O.B.
1696	Aug.-Sept.	China (Yunnan), Yunnan Fu I Ho.
1697		Italy, Naples, in consequence of an eruption of Vesuvius I B.
1697	Feb. 25-26	Mexico, *Acapulco*, San Marcos III Bo. & O.B.
1697	Feb. to Mar.	China (Anhui), Luchou I Ho.
1697	Mar. 24	Mexico, *Acapulco* III M.
1697	June 18	Italy, Florence I B.
1697	Sept.-Dec.	Italy, Siena I B.
1697	Nov. 25	Japan, Kamakura II O.
1698	Jan. 18-20	China (Shantung), Fushan in Tengchou Fu I Ho.
1698	April 12	Italy, *Vizzini*, *Militello* in (Catania) and Palermo II B.

A.D.		
1698	June 19	Ecuador, the Andes about Quito, *Ambato*, Riobamba and *Latacunga* II M. R. & S. give III.
1699	July 14	Peru, Lima I H.J.
1699	Sept. 23	Japan (Kii) III O.
1699	Sept. 24 ?	Philippines, Manila II S.M.
1700	Mar. 16	China (Kueichou) I Pa.
1700	April 16	Japan (Tsushima) II O.
1700	May 4	China (Hupeh), Chishui, Kuangchi in Huangchou Fu I Ho.
1700	June or July	Siberia, *Nerchinsk* I M. & O.
1700	July 28	Italy, Enemonzo, S. Stefano di Piano in (Udine) II B.
1701	Dec. 21	Mexico, *Oaxaca Town* and Mexico II O.B.
1702	Mar. 14	Italy, Benevento, Aprice, Ariano and surrounding towns III B.
1702	Sept.	West Indies, Martinique II M.
1703	Jan. 14-Feb. 2	Italy, Norcia in (Perugia), Aquila in (Abruzzi), other towns in these departments and in the (Marches) III B.
1703	January	Italy, Montebello in (Verona) I B.
1703		Ecuador, Latacunga III R.S.
1703	Nov. 21	Mexico, Mexico City I O.B.
1703	Dec. 30	Japan (Musashi), Tokio; (Sagami), Odawara; (Awa, Kazusa, Shimosa, Hitachi, Kotsuke, Shimotsuke, Mutsu) III Mi.
1704		England, Lincoln I M. & W.
1704	Nov. 10-Jan.	Grecian Archipelago, Island of Santa Maura I M.
1705	Nov. 2	China (Chihli), Miyun in Shuntien Fu I Ho.
1705	Nov. 26	Peru, *Arequipa, Arica*; sea waves. II M.
1705	Nov.-Dec.	China (Fukien), Fuchou Fu, Hsinghua Fu I Ho.
1706	April 20	Iceland, Olfus, Floi and *Faxafloi* area; many farms fell III Th. Also Jan. 28, March and April 1.
1706	Oct. 21	Japan, Tokio; (Loochoo) I Mi.
1706	Nov. 3	Italy, *Campobasso*, Manopello in (Abruzzi) III B.
1707	Mar. 24	Italy, Acquasparta and neighbourhood in Perugia I B.
1707	Sept.-Oct.	China (Yunnan), Lufeng in Yunnan Fu, Yunchou in Shunning Fu I Ho.
1707	Oct. 28	Japan, Tokaido, Kiushu, Shikoku, Chugoku; (Tosa), with sea waves III Mi.
1707	Dec. 16	Japan, Osaka; (Kii, Mikawa, Totomi, Ise, Suruga) III O.
1707		Salvador, San Salvador III Mon.
1709	Mar. 11	Japan (Mimasaka, Inaba, Hoki) II O.
1709	Oct. 14-15	China (Shensi), Chengku in Hanchung Fu; (Kansu), Hsining Fu; (Honan), Chungmou in Kaifeng Fu; (Chihli), Chulu in Shuntien Fu II Ho.
1710	May 16-17	Greece, Zante I P.
1711	Jan. to Feb.	Italy, Reggio in (Calabria, Messina) I B.
1711	June 26	China (Fukien), Yuchi, Yenping, Sha in Yenping Fu I Ho.
1711	Aug. 16	Mexico, Mexico City, *Tlaxcala*, Colima, *Guadalajara* in Jalisco, Oaxaca, Puebla and east and south of country III O.B.
1711	Aug. 31 to Sept.	China (Fukien), Changchou, Changpu, Nanching, Changtai, Pingho, etc., in Changchou Fu and Chuanchou Fu II Ho.
1711	Oct. to Nov.	Formosa, Taihoku I H.
1712	April 10	Austria, in and around Vienna, especially at *Neustadt* I M.
1712		Italy, Rome I B.
1712	May	Italy, *Campobasso*, Naples and Benevento II B.
1712	July 16	Italy, Bruzzano, Stilo in (Calabria) I B.
1713	Jan. 3-6	Italy, Massafra in (Lecce) and Bari I B.
1713	Feb. to Mar.	China (Yunnan), Yunnan Fu, Linan Fu, Chuhsiung Fu, Kuanghsichou, Chuching Fu II Ho.
1713	Aug. 25	China (Ssuchuan), Mou II Pa.
1714		Italy, Narni in (Perugia) II B.
1714	Jan. 13	Belgium, Brabant, Hainhault, Liège, also at *Brussels* and *Maestricht* II M.
1714	April 28	Japan (Shinano) II O.

A.D.		
1714	May 5	Mexico, *Cordoba* and *Orizaba* in Vera Cruz, Oaxaca III O.B.
1714	July 27	Greece, Patras II M.
1714	Aug.	Italy, Salerno II B.
1714	Aug. 28	Greece, Cephalonia III P.
1714	Sept. 3	Greece, in the Morea, *Patras* I M.
1715	Aug. 22	Peru, Moquegua I Mon.
1715	Oct.	Formosa I H.
1716	Feb. 3	Algiers II M.
1716	Feb. 6	Peru, *Moquegua*, Torata I H.J.
1716	Feb. 6	Mexico, Coast of Lower Califorina III O.B.
1716	Feb. 21	Italy, *Castroreale* in (Messina), and elsewhere in (Catania) II B.
1716	May-June	Algiers, 20,000 perished; also felt at Catania and Syracuse III M.
1716	Sept. 21	Philippines, S. Luzon (Rizal, Laguna, Cavite and Batangas), *Taal* II S.M.
1716		Central Asia, through the whole of the district Sungaria, 45°N. 88°E., between the lakes Balkash and Zaisang 48°N. 84°E., *Aksu* III M.
1717	Feb. 13	Japan (Hyuga) I O.
1717	April 4	Italy, Vittoria in (Syracuse) I B.
1717	April 22	Italy, *Castroreale* and other towns in Messina II B.
1717	Aug. 5	Algiers I M.
1717		Asia Minor, *Caesarea* I M.
1718		West Indies, Martinique, also at St. Vincent I P.
1718	Feb. 20	Italy, Sicily (Syracuse and Catania) I B.
1718	Mar. 10	Italy, Noto in Syracuse II B.
1718	May-June	China (Kansu), Tungwei in Kungchang Fu I Ho.
1718	June 10	China (Shensi), Fenghsiang Fu; (Kansu), Li, Chinan in Chinchou Circuit II Ho. M. & O. give June 8, Shensi and Shansi
1718	June 15-16	Austria, Neustadt, near Vienna and the neighbourhood II M.
1718	Aug. 3	China (Kansu), Pingliang and Kungchang III Pa. The date is that of a notification, see June 10.
1718	Aug. 22	Japan (Yamashiro, Shinano, Totomi, Mikawa) III O.
1718	Dec. 10	Island of Cyprus; the capital destroyed III M.
1719	Jan 7	Italy, Friuli in (Udine) I B.
1719	Mar. 6	Turkey, *Constantinople*, also at Villanova in (Algarbia), Portugal II M.
1719	Mar. 6	Asia Minor, Smyrna and *Aleppo*; 200 houses ruined II M.
1719	Mar. 6	Salvador, San Salvador III Mon.
1719	May 25	Turkey, *Constantinople* and in Anatolia, between Scutari and Ile des Princes, town of *Serenit* or *Ismid* and at *Nicomedia* III M.
1719	June to Aug.	China (Chihli), Hsuan Fu, Shuntien Fu and Tiensen II Ho.
1719	July	Northern China III M. & O. See above.
1719	June 27	Italy, Norcia in (Perugia) and neighbouring towns II B
1719	July	Morocco, *Morocco*, along the coast of Fez II M.
1720	April	Peru, *Guamanga* II M.
1720	June 11-12	China (Chihli), Yenching in Hsuanhua Fu I Ho.
1720	June to July	China (Kiangsu), Chenchiang Fu, Sungchiang Fu I Ho.
1720	July 15	India, Delhi III Ol.
1720	July 11-13	China (Chihli), *Huailai*, *Huaijou*, *Miyun*, Tungan in Shuntien Fu, Paoting Fu, *Yuchou* in Hsuanhua Fu III Ho.
1720	July to Aug.	China (Shantung), Chinan Fu; (Chihli), Tiensin, Hsuanhua Fu II Ho.
1720	Aug. 27-28	Italy, *Montecassino* and Atina in (Caserta) II B.
1720	Sept. 12	Italy, Gerace in (Calabria) II B.
1720	Nov. 1	Formosa, Tainan III H.
1721	Jan. 5	Formosa, Tainad III H.
1721	Mar. 24	Island of Majorca, R. Selva I M.
1721	April 26	Persia, *Tabriz*, 8,000 lives lost III M.
1721	July 3	Throughout the whole of Switzerland, especially in the Canton of (Bâle), at Wallenbuch, Porrentrui, Muhlhausen, in the Canton of (Berne) along the Aar, Lucerne, Zurich and Strasburg I M.

A.D.		
1722	Feb.-Mar.	China (Yunnan), Yunnan Fu, Linan Fu I Ho.
1722	May 3	China (Honan), Kaifeng Fu, Huaiching Fu I Ho.
1722	May 24	Chile, Santiago I M., Mon. & P.
1722	Nov. 20	Algiers I M.
1722	Dec. 27	Portugal, Villanova and all the south coast from Cape St. Vincent; the sea was agitated; Albufeira, Loule, Silves, Faro, Tavira II M.
1722		Formosa, Hozanken I H.
1723	Feb. 20	Costa Rica, Cartago I O.D.
1723	Dec. 17	Japan, Kiushu II Mi.
1723	June-July	Italy, Roccamonfina in (Caserta) I B.
1724	May 17	Iceland, Myvatnssveit (Northland); eruption at Myvatn II ? Th.
1724	May 24	Chile, Santiago I Mon.
1724	Aug.	Iceland, Arnessysla (Southland), Krisuvik in the Faxafloi and also Reykjanesskaga II Th.
1724	Sept. 3	Italy, Reggio (Calabria) I B.
1724	Oct. 12	Portugal, Lisbon I M.
1724	Dec.	China (Yunnan), Yunnan Fu, Chuching Fu, Chengchiang Fu II Ho.
1724	Dec. 11	Italy, *Travali*, Monte Ingegnoli and *Fosini* (Siena) II B.
1725	Jan. 8	Peru (Ancachs), Lima, Arequipa III P. & Mon. H.J. gives Jan. 6.
1725	Jan. 21	Siberia, Chita in Transbaikalia and west to River Selenga I M. & O.
1725	Mar. 27	Peru (Arequipa), Camana II H.J.
1725	April 1 & 2	Iceland (Southland), Arnes and Rangarsysla, with eruption of Hecla III Th.
1725	Oct. 28 ?	Italy, *Modigliano*, Faenza, Brisighella and other towns in Romagna II B.
1725	Oct. 30	Japan, Nagasaki III Mi.
1725	Jan. 8	Peru, Lima, Arequipa III Mon.
1726	Mar. 19	Japan, Echizen II O.
1726	April 9	Italy, Monte Olivetto (Siena) I B.
1726	April 15	Turkey in Asia, Aleppo, also at Alexandria I M.
1726	July 20	China (Hupeh), Changyang, Yichang in Yichang Fu I Ho.
1726	Summer	Iceland, Southland, Rangarvellir, also eruption in the Eastern Jokulls; two farms fell II Th.
1726	Sept. 1	Italy, *Palermo*, Marsala and Mazzara II B.
1726	Sept. 26	Italy, Trapani in Sicily II B.
1727	Jan. 5-7	Italy, Noto (Syracuse) I B.
1727	Mar. 10 & 18	Mexico, Oaxaca town II O.B.
1727	May 12	Germany, Frankfort on the Main I M.
1727	May-Oct.	Italy, Sciacca in Girgenti I B.
1727	Nov. 7-27	West Indies, Martinique II M. & P.
1727	Nov. 8	United States America, Newbury (Massachussetts) I F.R.
1727	Nov 18	Persia, Tabriz, 77,000 people perished III M.
1727	Dec. 15	Italy, Monastery of St. Michael (Urbino) I B.
1728	Feb. 8	Italy, Roccamonfina in (Caserta) I B.
1728	April 18	Iceland, Myvatn I Th.
1728	Nov. 28	Philippines, S. Luzon, especially at *Manila* III S.M.
1729	Jan. 13	A great part of Switzerland, especially at (Berne), lakes of Thun and Brienz, at *Interlachen*, Spiez, Zurich, *Frulingen*, Rettingen, *Constance*, Bâle, *Lausanne*, Geneva, Vevey and throughout the Canton du Vaud I M.
1729	June 28-29 July 9 or	Italy, Patti, Millazzo, Castroreale in Messina I B.
1729	June 28	Greek Calendar. Greece, Zante II P.
1729	Aug. 1	Japan (Noto, Sado) II O.
1730	Mar. 12	Japan (Tsushima) II O.
1730	Mar. 28	Italy, Massa in (Carrara) II B.
1730	May 12	Italy, Norcia and environs in (Perugia) II B.
1730	June	Italy, San Ginesio (Macerata) I B.
1730	July 8-9	Chile, Concepcion, Santiago, with sea waves III M., P. & Mon.
1730	-	Philippines, S. Luzon (Laguna and Tayabas) III S.M.

A.D.		
1730	Sept. 21	Formosa, Tamsui, Kagi, Shoka I H.
1730	Sept. 29 & 30	China (Chihli), Pekin, Paoting Fu, Yungping Fu, Hochien Fu, Tientsin III H.
1730	Sept.-Oct.	China (Chihli), Chengting Fu, Chichou, Hsuanhua Fu; (Shangtung), Chinan Fu, Chingchou Fu II Ho.
1731	Mar. 20	Italy, Foggia (Apulia) II B.
1731	Oct. 7	Japan (Matsu) II O.
1731	Nov. 7 & 15	Mexico, Mexico City I O.B.
1731	End of year	Italy, Mountains of (Pistoia) II B.
1731	Oct. 22	China (Fukien), Hsinghua Fu, Changchou Fu I Ho.
1731	Oct. to Nov.	China (Kiangsu), Huchou Fu, Yangchou Fu, Tungchou, Haichou II Ho.
1732	Jan. 10	Spain, Seville I M.
1732	Jan. 20	China (Yunnan), Yunnan Fu, Tungchuan Fu; (Ssuchuan), Ninguan Fu II Ho.
1732	Jan. 29	Japan (Tokio) I O.
1732	Feb. 4	Italy, Parma I B.
1732	Feb. 25	Mexico, Acapulco; extraordinary flux and reflux of the sea II M.
1732	Mar. 28	Italy, Milazzo, Castroreale (Messina) I B.
1732	Aug. 9-10	Italy, Imola, Forli, Faenza in (Emilia) I B.
1732	Sept. 5	Canada, Montreal, also at Boston (Pennsylvania) and at Annapolis (Maryland) I M.
1732	Sept. 7	Iceland, Rangarvellir and Eystrihreppr II Th.
1732	Sept. 15	Noon, U.S.A., Newbury, Massachusetts; felt at Boston, Montreal II F.R.
1732	Nov. 29	Italy, *Ariano* and other towns in (Avellino) III B.
1733	Jan. 29	Italy, Calabritto (Avellino) I B.
1733	July-Aug.	China (Yunnan), Tungchuan Fu, Chanyi in Chuching Fu I Ho.
1734	Aug.	Ireland II R.
1734	Mar. 21	Iceland, Arnessysla, Floi; 60-70 farms fell II Th.
1734		Bolivia, Mision de Tarija en el Chaco? I Mon.
1734	Aug. 17	Mexico, throughout the country III O.B.
1735	Feb. 2	Colombia, Popayan III R.S.
1735	May 30	Mexico, throughout the country III O.B.
1735	Sept. 6	China (Chehkiang), Tunghsiang in Chiahsing Fu, Huchou Fu I Ho.
1735	Sept. 6	Italy, Monteleone, Pizzo (Catanzaro) I B.
1736	Jan. 27	Formosa, Tainan, Kagi, Shoka III H.
1736	May 1	Scotland, Ochil Hills I? M.
1736	June 12	Switzerland, throughout the whole country round, *Bâle* I M.
1736	Aug. 16	Italy, Ciminna, Naso (Messina) II B.
1736	Dec. 5	Ecuador, Quito III R.S.
1736	Dec. 25	China (Shantung), *Huang*, Hushan, Wenteng in Tengchou Fu I Ho.
1737	May 14	Swabia, Carlswich, Carlsruhe? I M.
1737	End of May	Turkey, Constantinople I M.
1737	June 11	Italy, San Casciano in Florence I B.
1737	Sept. 23 to Oct. 23	Siberia, *Nizhne-Kamtchatka* II M. & O.
1737	Oct. 6	Siberia, Kamtchatka and Kuriles, around *Avacha* III M. & O.
1737	Oct. 11	India, Calcutta; 300,000 lives lost III Ol.
1737	Oct. 18	France (Vaucluse), Carpentras I M.
1737	Dec. 6	Siberia, Kamtchatka and the Kuriles II M. & O.
1737	Dec. 17	U.S.A., *New York*; felt in Boston and other places I F.R.
1737	Dec. 24	Chile, ruin of Valdivia III? Mon.
1738	Aug.?	Italy, Bagnorea (Latium) II B.
1738	Aug. 16	Italy, Catania, Noto and Syracuse I B.
1738	Nov. 5-6	Italy, Parma, Mirandola, Verona I B.
1739	Jan. 3	China (Shensi), Hsian Fu I Ho.
1739	Feb. 4	Servia, Obrez near Yagodina, Morava Valley II O.D.
1739	Feb. 13	Italy, Foggia (Apulia) I B.
1739	May	Italy, Naso in Messina II B.
1739	July 14	Mexico, Colima II O.B.
1739	Dec. 24	China (Shensi), Paishui in Tungchou Fu, Chishan in Fenghsiang Fu I Ho.

A.D.		
1740	Mar. 6	Italy, Salemi in Trapani II B.
1740	Mar. 6	Italy, Barga in Garfagnano, Castelnuovo, Fanano, Modena, etc. II B.
1740	June 13	Italy, Sciacca in Girgenti II B.
1740	Aug. 25	Mexico, *Oaxaca* and Mexico II O.B.
1740	Aug.-Oct.	China (Chihli), Wanchuan in Hsuanhua Fu I Ho.
1741	April 15	Italy, Cremona I B.
1741	April 24	Italy, *Fabriano*, Urbino, Fano, Camerino, Pesaro in the (Marches) III B.
1741	Aug. 25	Chile, Wagerid I P.
1741	Oct. 1	Italy, Siena I B.
1742	Jan. 1	Italy, Leghorn II B.
1742	Feb. 7	Behring Island II M. & O.
1742	Feb. 14	Greece, Zante II P.
1742	Mar. 23	Chile, north of the Taytao Peninsula and south of the Chonos Archipelago I Mon.
1742	June 16	Siberia, Irkutsk I M. & O.
1742	June 16	Siberia, Behring Island III M. & O. See Feb. 7.
1742	Sept.	China (Chihli), Huaian in Hsuanhua I Ho.
1743	Feb. 20	Malta and Italy (Terra d'Otranto, Calabria, Messina), also Cephalonia III B. & P.
1741, 1742, 1743		Chile, various earthquakes in the islands of Wager and Chiloe, also Valparaiso I Mon.
1743	May 29	Italy, Ferrara I B.
1743		Philippines, S. Luzon (Laguna and Tayabas) III S.M.
1743-45		Italy (Calabria, Messina) II B.
1743	Oct. 18	Colombia, Bogota, Chia I O.D.
1745	March	Italy, Spoleto (Perugia) I B.
1745		Greece, Corfu II M.
1745	Oct.	Italy, Montecassino (Caserta) I B.
1746	May 14	Japan, Tokio I O.
1746	Mar. to July	China (Kuangtung), Kuangchou, Sanshui, Tsengcheng in Kuangchou Fu I Ho.
1746	July	Italy, Barga in Garfagnano I B.
1746	Oct. 8	Italy, Orsaria (Friuli) I B.
1746	Oct. 28	Peru, Lima III H.J.
1747	April 17	Italy, Nocera (Umbria) II B.
1747		Peru, Carabaya I H.J.
1747	Sept.	Italy, Reggio (Calabria) I B.
1748	Mar. 23	Mexico, *Mexico* and Oaxaca I O.B
1749	June 8	Austria, Neustadt I Ra.
1749	Aug. 12	1h. 0m., G.M.T. Philippines, S. Luzon, Manila (Rizal, Laguna, Cavite, Batangas), N. Mindoro III S.M.
1749		Iceland, Southland, Olfus, Borgatjirdr, Faxafloi area II Th.
1749 & 1750		Mexico, Colima, *Sayula*, *Zapotlan*, and *Amacuepan* in (Jalisco) III O.B.
1750	Jan. 28	Italy, Frascati, Albano (Latium) I B.
1750	Feb. 1	Italy, Aquila (Abruzzi) I B.
1750	Feb. 19	England, London I M.
1750	Mar. 19	England, London I ? M.
1750	May 24	South France, in and about the Pyrenees, also at Rodez, Montpellier, Narbonne, Toulouse, Medoc, Pons in Saintonge, Macaire in Guyenne, Bordeaux and 12 leagues to the west of Bordeaux, *Tarbes* II M.
1750	June 7	Greece, Morea and the Island of *Cerigo*; 2,000 persons perished III M.
1750	June 24	Bavaria, Munich and Landshut II M.
1750	Sept. 17	Italy, Fiume (Udine) I B.
1750	Oct. 11	England, Northampton and Leicester I M. & W.
1750		Roumania, especially at *Philippopolis* II M.
1751	Mar. 24	Japan, Kioto II Mi.
1751	Mar. 25	Chile, Concepcion; sea waves III Mon.
1751	May 20	Japan (Echigo) III Mi.
1751	May 24	Chile, *Concepcion*, Santiago, Juan Fernandez; sea waves III P.
1751	May 25 & 30	China (Yunnan), Yunnan, Tengchuan in Tali Fu, Hoching in Lichiang Fu, Menghua II Ho.
1751	July 26	Italy, Gualdo, Nocera and other towns in (Umbria) II B. & M.

A.D.		
1751	Aug.	Italy, Palermo I B.
1751	Sept. 25	Italy, Narni in (Perugia) II B.
1751	Nov. 21	West Indies, St. Domingo, *Port-au-Prince* II M.
1751	Nov. 21	Italy, Eastern Riviera I B.
1751	Dec. 19	Portugal (Traz-os-Montes), *Torre-de-Moncorvo* I M.
1752	Feb. 16	Italy, Nizza and Oneglia I B.
1752	Feb. 23	England, Dartmoor I M. & W.
1752	Mar. 27	Portugal, at the mouths of the Mondego and Vouga, Averro II M.
1752	May 17	China (Chehkiang), Chuhsing, Haiyen, Tunghsiung in Chiausing Fu, Huchou Fu I Ho.
1752	Beginning of June	Greece, Zante II M.
1752	July to Aug.	Formosa, Shoka, Kagi I H.
1752	Aug. ?	Italy, Citta di Castello (Perugia) I B.
1752	Sept.	Italy, Frascati, Velletri and Marino in (Latium) I B.
1752	Winter	Iceland, Olfus, 11-12 farms and one church fell II Th.
1753	Feb. 11	Japan, Kioto I O.
1753	Feb.	Italy, Modena I B.
1753	Mar. 9	Italy, Luserna, Perosa, Susa (Piedmont) I B.
1753	April 2	Italy, Citta di Pieve (Perugia) I B.
1753	May 26	Italy, San Gemini (Perugia) I B.
1753	Dec.	China (Yunnan), Ning in Linan Fu III Ho.
1754	Jan. 12	France, Vorreppe, two leagues from Grenoble II M.
1754	May 15	13h. 0m. G.M.T. Philippines, S. Luzon (Batangas, Mindoro, Cavite, Tayabas, Laguna), Manila II S.M.
1754	May	Formosa, Tamsui II H.
1754	Sept. 1	Mexico, *Acapulco*, Mexico ; sea waves III O.B.
1754	Sept. 2	Turkey, *Constantinople*, *Nicomedia*, also at Adrianople and Asia Minor, Diarbekir, and Armenia, and at Alexandria and Cairo in Egypt II M. ? two earthquakes.
1754		Iceland, Krisuvik I Th.
1755	Feb. 8	China (Yunnen), Yihmen and *Linan Fu* II Ho.
1755	Feb. 26	Servia, Vranje, Mastanica, Ristobac II O.D.
1755	April 21	Japan, Nikko I O.
1755	April 26	Ecuador, Quito III R.S.
1755	June 7	Northern Persia, Tabriz, *Kaschan*, Ispahan and Taurus, 40,000 perished III M.
1755	Sept. 11-24	Iceland, Skagafjordr, Eyafjordr, Skjalfandi, north coast Husavik, with eruption of Katla III Th.
1755	Oct. 15	Italy, Chambéry in Savoy I B.
1755	Nov. 1	Italy, Island of Ponza I B. The Lisbon earthquake.
1755	Nov. 1	Portugal, the Great Earthquake of *Lisbon*. *Faro*, *Setuval*, *Cascaez*, slight damage at most of the towns in Portugal, *Seville*, *St. Lucar*, *Xeres*, strong in south Spain; sea waves III M.
1755	Nov. 8	Spain, Lisbon II M.
1755	Nov. 17	Spain, Gibraltar II M.
1755	Nov. 17	England (Herefordshire) I M. & W.
1755	Nov. 18	U.S.A., New England, provinces of (Massachusetts and New Hampshire), also at New York, Philadelphia, Chesapeake Bay in Maryland, Annapolis, also at Halifax, Lake St. George II M.
1755	Nov. 19	Spain, Gibraltar I M.
1755		Azores, seismic or volcanic ? M.
1755	Nov. 19	Morocco, *Mequinez*, slight shocks were felt along Rhine, the in the Breisgau, at Aix in Savoy III M.
1755	Dec. 9	Switzerland, *Brieg*, *Valais* I B.
1755	Dec. 9	Throughout Switzerland and parts of France, Bavaria, Swabia, the Tyrol, the Italian Alps, Turin, Milan, Piedmont, Savoy, Naples, *Brieg* and the *Valais*, the whole chain of the Alps and Jura, Chiavenna, Aigle, Lake of Geneva, *Glisa*, *Natria* II M.
1755	Dec. 21	Switzerland, *Brieg*, also violent shocks the whole country round, also Lisbon and Algarbia, Algarve ? III M.
1755	Dec. 26-27	Germany and Belgium, Lower Rhine, Maestricht, Sedan, *Brussels*, *Liège*, *Chesnée* and Cologne I M.
1755	Dec. 30	Switzerland, Brieg I M.
1755-6		Italy, Ancona I B.

A.D.		
1756	Jan. 2 & 3	China (Kiangsu), Suchou Fu ; (Chehkiang), Tunghsiang in Chiahsing Fu, Huchou Fu II Ho.
1756	Jan. 2	Ireland, Ballymore I M. & W.
1756	Jan. 15	Switzerland, Brieg I M.
1756	Feb. 18	The Alps, parts of France and Germany, Netherlands, England, Portugal, *Liège*, *Cologne* I M.
1756	Feb. 19	Switzerland, Bireg I M.
1756	Mar. 11	Portugal, Lisbon II M.
1756	April 13	Italy, Padua, Verona and *Trevisa* I M.
1756	Aug. 17	Italy, Padua I B.
1756	Aug. 25	Japan (Omi) I Mi.
1756	Oct. 22	Italy, *Naples*, Calabria, Sicily and Greece I B.
1756		Siberia, Kamtchatka III M. & O.
1756	Dec. 1	Portugal, Cascaes, Cintra, Colares, Ozyrat ? and *Sezimbra ?* II M.
1756	Dec. 7	China (Kiangsi), Jaochou Fu, Juichou Fu ; (Chehkiang), Chiahsing Fu, Huchou Fu II Ho.
1756	Dec. 13	China (Anhui), Huichou Fu, Chihchou Fu I Ho.
1757	Feb. 22	Ecuador, Latacunga III R.S.
1757	Mar. 18	Portugal, Lisbon, *Cascaes* II M.
1757	April or May 15	Morocco, Salee on the coast I M.
1757	July 9	Throughout the Azores, *Angra* (Terceira), Island of St. George ; sea waves III M.
1757	July 10	Throughout the Azores, Norte Grande, Island of *St. George*, Island of *Topo* II M. See above.
1757	Aug. 6	Italy, *Syracuse* II B.
1757	Dec. 14	West Indies, Cuba, Santiago I O.D.
1758	Beginning of January	North Africa, *Constantine* and at *Tunis* III M.
1758	Dec. 3 & 4	Turkey, Constantinople I M.
1758	Dec. 6	Russian Lapland, along the White Sea, at Kola and the environs I M. M. & O. give II
1759	Mar. 30	Italy, Pinerolo (Turin) II B.
1759	June 29 and following days	Mexico, frequent violent shocks ; volcano Jorullo formed in (Michoacan) III O.B.
1759	June 29	Turkey, Salonica and the town of *Philippopolis* I M.
1759	Aug. 10	France, Bordeaux, Limoges and (Limousin) I M.
1759	Sept. 28 & 29	Mexico, the region round S. Pedro de Jorullo I M.
1759	Oct. 30	Asia Minor, Aleppo, Damascus, Tripoli, coasts of Syria, *Valley of Baalbek*, the centre being at *Saphet* ; at Acre the sea rose III M.
1759	Nov. 26 & 28	Asia Minor, Aleppo, Saphet, Damascus, Tripoli, coast of Syria II M.
1759	Dec. 22	Sweden, *Gothenburg*, Jonköping, Œrebro ? and Cluncur ? I M.
1760	Mar. 25	China (Kansu), Chenyuan in Ching Circuit I Ho.
1761	Mar. 31	Spain and Portugal, Lisbon, *Oporto*, felt as far as Madrid, Santa Cruz in Barbary, Bordeaux in France, Amsterdam in Holland, Cork in Ireland, Funchal in Madeira, and in the Azores II M.
1761	April 5	Italy, Montecassino (Caserta) I B.
1761	April 9	North Africa, Barbary, Santa Cruz I M.
1761	Dec. 9	Central Asia, north-west of Altai, Shulbinsk, Semipalatinsk, Barnoul to Ust-Kamenogorski I M.
1762	April 2	India, felt all over Bengal, Arracan, and Burmah, Pegu, north-east coast of Bay of Bengal elevated along a length of 100 miles, Brahmaputra to Calcutta, Dacca, Ghirotty, Chittagong and Bakar Tschurak II M. & Ol.
1762	April 17	Italy, Mugello (Tuscany) II B.
1762	July	Italy, Cassamicciola (Ischia) I B.
1762	Oct. 6	Italy, Poggio, Picenze and other places in (Aquila) II B.
1762	Oct. 31	Japan (Sado) II O.
1762	Nov. 6	Spain, Aquila II M.
1762	Nov. 8	West Indies, Jamaica I M.
1763	January	Colombia, Department of Cauca I O.D.
1763	Feb. to June	Italy, Bronte, Paternò, Nicolosi (Catania) ; connected with opening of a crater I B.
1763	June 28	Hungary, *Comorn*, Raab, *Pesth*, Buda, Kerepas, *Temeswar*, *Belgrade*, Leobersdorf II M. & Ra.

A.D.		
1763	July 29	Hungary, *Comorn*, also at Raab III M.
1763	Aug. 9	Hungary, Raab II M.
1763	Sept. 1	Moluccas II M.
1763	December	China (Yunnan), *Chiangchuan* in Chengchiang Fu, Hoshi, Tunghia in Linan Fu III Ho.
1764	June 4	India, on the banks of the Ganges II M. & Ol.
1764	June 27	China (Kiangsu), *Lishui* in Kiangning Fu, Suchou Fu, Changchou Fu II Ho.
1764	Oct. 12	Azores, *Fayal* II M.
1764	Dec. 2 & 3	Hungary, Peterwaradin I M.
1765	April	Central America, San Salvador, San Cristoval, Ilopango, San Martin, San Pedro-Perulapam, San Partolome-Perulapilla III Mon.
1765	May 10	France, French side of the Pyrenees I M.
1765	Sept. 2	China (Shensi), Fenghsiang Fu I Ho.
1765	Sept. 3	China (Chehkiang), *Chingning* in Chuchou Fu III Ho.
1765	Oct. 24	Guatemala, Mexico, Tehuantepec ? *Suchiltepequez* III Mon.
1766	Feb. 28	Sweden (Halland), Harstoeff I M.
1766	Mar. 5	Japan, Oshiu, Awomori, Tsuruga III Mi.
1766	April 5-21	Iceland, Southland ; three farms fell in Olfus, Arnessysla ; eruption of Hecla I Th.
1766	May 22	Turkey, *Constantinople* and several other towns II M.
1766	June 11	West Indies. Jamaica, Port Royal and *Cuba, Santiago* III M.
1766	July 24 ?	Greece, Zante and Cephalonia II P.
1766	Aug. 5	Austria, Hungary, Turkey, Vienna, S. Marguerita, *Constantinople, Adrianople*, Gallipoli, Salonica, Smyrna, Enos, Tenedos and Brussa II M.
1766	Aug. 25	West Indies, Martinique, *St. Pierre* II M.
1766	End of Sept.	West Indies, Cuba, *St. Jago* or Santiago III M.
1766		Armenia, Pasin, Hassan II M. & O.
1766	Oct. 21	Venezuela, *Cumana and Caracas ;* New Granada, Island of Trinidad, Surinam and all the north-eastern portion of S. America III M.
1766	Dec. 7	2h. 45m., G.M.T. Philippines, Manila I S.M.
1766	Dec. 24-25	Italy, Foligno and Norcia (Perugia) I B.
1767	Jan. 12	Turkey, Constantinople I M.
1767		Italy, Rotaro in Ischia I B.
1767	Jan. 21	Italy, Fivizzano (Tuscany) II B.
1767	Feb. 8	7th, 17h. 5m., G.M.T. Philippines, Manila and neighbouring provinces I S.M.
1767	Feb. 7	Italy (Liguria), Genoa and other places I B.
1767	April 13	Germany, Gotha, Cassel, Gottingen, Helmstadt, Mulhausen, *Rothenburg* I M.
1767	May 26	Italy, Val di Lanzo (Piedmont) I B.
1767	June 4-5	Italy, Spoleto (Perugia) II B.
1767	July 14-15	Italy, Luzzi, S. Agata in Cosenza and felt as far as Gallipoli II B.
1767	July 11 & 24	Greece, Island of Cephalonia, Zante, *St. Maura* III M.
1767	Nov. 13	7h. 25m., G.M.T. Philippines, S. Luzon, Manila and neighbouring provinces I S.M.
1768	Feb. 27	Austria, Vienna, *Neustadt*, Presburg, Bischoffswerder and Freiberg I M. & Ra.
1768	Mar.-April	China (Kansu), Chenyuan in Chingchou Circuit I Ho.
1768	April 3 & 4	Mexico, Mexico, Puebla and Vera Cruz II O.B.
1768	May 15	England, Manchester I M. & W.
1768	Oct. 19-20	Italy, Santa Sofia (Florence) II B.
1769	May 1	Turkey, Bagdad III M. Partly hurricane.
1769	Aug. 29	Japan (*Hyuga*) II O.
1769	Oct. 24	Siberia, Irkutsk and Selenginsk I M.
1769	Nov. 18	France, Avignon and near *Roquemaure* and *Bedarrides* II M.
1769	Nov.	Scotland, Inverness I M. & W.
1770	January	China (Anhui), Chichi in Huichou Fu ; (Kiangsi), Pengtse in Chiuchiang Fu I Ho.
1770	End of Jan.	Greece, St. Maura, 760 houses destroyed III M.
1770	June 3	West Indies, Western part of St. Domingo, *Port-au-Prince* III M.
1770	June	Italy, Reggio (Calabria and Messina) I B.

A.D.		
1770	Nov. 3	Saxony, Schomberg I M.
1770	Dec. 27	Italy, Upper Valdarno (Tuscany) I B.
1771	Jan. 8	Italy, Leghorn I B.
1771	Jan. 28-April	Italy, Alba in Cuneo I B.
1771	Feb. 1	Philippines, S. Luzon, Manila (Rizal, Cavite and Laguna) II S.M.
1771	First half of Feb.	West Indies, Martinique, *St. Pierre, Port Royal* I M.
1771	Aug. 7	Siberia, The Ostrog of Tounkiskinskoi ? near Zaisan Nor I M.
1771	Sept. 3	West Indies, Jamaica I M.
1771	Oct. 3	West Indies, St. Domingo II P.
1772	Jan. 2	France, Parthenay, Department of Deux-Sèvres II M.
1772	Feb. 18	Russian Lapland, in the neighbourhood of Kola I M.
1772	April 5	Portugal, Lisbon I M.
1772	Aug.	China (Yunnan), *Yunnan*, Tali Fu III Ho.
1772	Sept. 13	Switzerland, in the Tyrol I M.
1772	Oct.	France (Basses-Pyrénées), Arudy I M.
1772	Dec. 5	Siberia, Irkutsk, Selenginsk and Kiakhta I M. & O.
1772		Caucasia, Beschtau mountains I M.
1773	Jan.	Morocco, at Old Fez II M.
1773	Jan. 16-24	France, *Tulette* near Claussayes (Dauphiny), Valréas, La Garde, Montélimar, St. Andéol and Viviers I M.
1773	Jan. 27 & 28	Hungary and Servia, Semlin and Belgrade I M.
1773	Feb. 24	France, Claussayes I M.
1773	April 12	Spain and Africa, Cadiz, Rota, S. Maria, Port Royal, Lisbon, Madrid, Malaga, Gibraltar, Salee and *Tangiers* II M.
1773	May 12	Greece, Corfu II M.
1773	May	Guatemala III Mon.
1773	June 3	Guatemala, *St. Jago* or Santiago ; 5,000 to 8,000 families lost their lives III M.
1773	July 29	Guatemala and Chile, *Santiago* in Guatemala, Copiapo in Chile III M. & Mon. This and the two previous entries probably refer to the same event.
1773	Nov. 25	France, Claussayes II M.
1773	Dec. 31	France, Montdauphin I M.
1774	Jan. 26 & 27	Prussia (Silesia), Ratibor I M.
1774	Mar. 4	Italy, Parma I M. & B.
1774	April	Formosa, Shoka, Kagi I H.
1774	July	Central America, Salvador, *Huizucar*, Huitza, Mexico ? *Panchimalco*, also coast from Acajutla and the Cordilleras III Mon.
1774	Sept. 10	Switzerland, *Altdorf* and Stirenzen II M.
1774	Oct. to Nov.	China (Kiangsu), Chingpu, Sungchiang in Sunchiang Fu I Ho.
1775	Mar. 17	Chile, Valparaiso I Mon.
1775	June to July	China, Yunnan, Chubsiung Fu I Ho.
1775	July 1 & 2	Guatemala III M. Possibly the same earthquake as the one recorded for 1773
1775	Oct. 22	Corsica, Vico I M.
1775	Dec. 30	France, Toulouse, *Alençon*, Havre, *Caen*, St. Lo and Falaise I M.
1776	Feb. 27	Malta I M.
1776	Mar. 29	Italy, Rieti (Perugia and in the Abruzzi) II B.
1776	April 21 to May 12	Mexico, S. and W. to Acapulco II M. & O.B.
1776	July 9 & 10	Austria and Italy, Trieste, Laibach, Tramonti (Udine), Venice and in the *Friuli* II M. & B. In Italy I
1776	Aug. 4	France, Carcassone (Dept. de l'Aude) I M.
1776	Nov. 28	Germany, Mannheim I M.
1776	Dec. 9	Siberia, Barguzin Fort, Transbaikalia I M. & O.
1776	Dec.	Formosa, Kagi III H.
1776-78		Italy, Cella and Abbadia, S. Salvatore, Radicofani (Tuscany) I B.
1777	Jan. 26	Peru, Lima I H.J.
1777		Mexico, Jalisco I O.B.
1777	Feb. 7	Switzerland, Lucerne, *Sarnen* I M.

A.D.		
1777	Aug. 19	Italy, Sora in Caserta I B.
1778	Jan. 18	Transylvania, Hermannstadt and on the borders of (Moldavia and Walachia), *Kronstadt* II M.
1778	Feb. 14	Japan (Aki, Bizen, Bitchu, Bingo) II O.
1778	June 16	Asia Minor, Smyrna II M.
1778	July 3	Asia Minor, Smyrna II M.
1778	Oct. 1	Asia Minor, Smyrna I M.
1778	Oct. 3	Asia Minor, Smyrna I M. Continuation of Oct. 1.
1778	Nov. 12, 13, and 14	Spain, Granada I M.
1779	Jan. 25	Venezuela, Caraccas I M.
1779	June and July	Italy, Bologna II M. & B.
1779	Aug. 1	Siberia, Irkutsk, Balagansk, Selenginsk I M. & O.
1779	Aug.-Dec.	Italy, Portice, Naples, Massa and Sorrento I B.
1779	Oct. 20	France, St. Girons in the Pyrenees I M.
1779	Nov. 8	Japan (Satsuma, Osumi) I O.
1779	Dec. 17	Japan (Sado) I O.
1780	Jan. 27	Malta I M. & B.
1780	Feb.-Mar. 3	Persia, Tabriz II M.
1780	April 16	Japan, Tokio I O.
1780	April-May	Italy, Sicily (Calabria), Lipari Islands I B.
1780	May	Japan, Chishima or Kurile Islands II O.
1780	Beginning of October	Island of Candia ; 13 villages disappeared III M
1780	Oct. 2	West Indies, Jamaica, Savanna, La Mar II P.
1781	April 4 or July 17	Italy, Faenza and Forli (Emilia) II B.
1781	April 13	Italy, Island of Ponza I B.
1781	June 3	Italy, Urbania, Sant Angelo, Apacchio, Piobicco, Cagli Palcano, etc. (Marches) and less violent over a large surrounding area III B.
1781	Sept. 10	Italy, Caravaggio, Treviglio, Carsano (Lombardy) I B.
1782		Peru and Venezuela, Arequipa, Cumana II O.D.
1782		West Indies, Cuba I O.D.
1782	Feb. 25	Italy, Ortona (Chieti) I B.
1782	May 15	Hungary, in the county of (Trentschin) II M.
1782	May 22	Argentina, Mendoza I Mon.
1782	July to Aug.	China (Chehkiang), Huchou Fu ; (Kiangsu), Suchou Fu, Sungchiang Fu I Ho.
1782	Aug. 15	France, Grenoble I M.
1782	Aug. 22	Japan, Tokio ; (Sagami) II Mi.
1782	Aug. 23	Japan, Tokio, Odawara ; (Uzen, Ugo) III Mi.
1782	Sept. 24	Italy, Monteporzio in (Latium) I B.
1782	End of Dec.	Hungary, Comorn II M.
1783	Feb.-Mar.	Italy (Calabria and Messina) and felt throughout Sicily and eastwards to Galipoli in Apulia III B.
1783	Mar. 4	Japan, Tokio I Mi.
1783	Mar. 26	Greece, Zante, Cephalonia, and St. Maura II P.
1783	April 11	Hungary, Comorn II M.
1783	April 22	Hungary, *Comorn*, along the Danube, Raab, Presburg, Pesth, Buda, Odenburg, Estherhaz II M.
1783	April 19	Philippines, N.W. Mindanao, around Dapitan Bay, Dapitan I S.M.
1783	July 28	Austria, Val di Ledro (Trent) in the Tyrol I B.
1783	Aug. 5	Japan (Shinano), Eastern Provinces I Mi.
1783	Nov. 15-16	Italy, Torremaggiore (Foggia) I B.
1783	End of Dec.	Guatemala II M.
1784	Mar. 20	Austria, Prague, the circle of Leutmeritz and the circle of Saaz as far as Eger, *Dur* I M.
1784	Mar.-April	Italy, Ariccia (Latium) I B.
1784	Good Friday	Chile, Arica, Valley of Tambo II Mon.
1784	May 13	Peru, Arequipa, the districts of *Camana* and *Moquegua* III M.
1784	July 23	Turkey, in the Paschalik of Erzerum and the city of *Erzingam* ; 5,000 people injured III M.
1784	July 29	West Indies, St. Domingo, Port-au-Prince, Goave, Léogane II M.
1784	Early in Aug.	Armenia, *Erivan*, extending to Erzerum, *Mush* and *Gurgur* III M. & O.

A.D.		
1784	Aug. 14-16	Iceland, Southland, Arnessysla, Rangarsysla; many hundred farms and some thousand houses fell III Th.
1784	Beginning of Sept.	Greece, *Cephalonia*, St. Maura and Argos I M.
1784	Oct.	Italy, Cossenza (Calabria) I B.
1784	Dec. 5 or	
1789	Nov. 29	France (Vosges), Neufchâteau, Rouchux I M.
1785	Jan. 30	Greece, Patras II P.
1785	Feb. 23	Russia, Mosdock on the Terek and the country round, Kislar, Astrakhan and the environs I M.
1785	Mar.-April	China (Fukien), Nanan in Chuanchou Fu I Ho.
1785	May 13	China (Kiangsu), Piyang in Hsuchou Fu, Yuhmen II Pa.
1785	June 26	Mexico, *Cholula* in Puebla and *Chilapa* in Guerrero II O.B.
1785	July	Italy, Cozenza I B.
1785	July 11	West Indies, Antigua II P.
1785	July 12	7.45 a.m. Columbia, Bogota, Ibagué II O.D.
1785	Aug. 22	Austria (Moravia and Silesia), *Ratibor* and *Pless* II M.
1785	Sept. 12	Italy, Val di Susa (Piedmont) II B.
1785	Oct. 1-2	Austria, Linz, Gallneukirchen and other places in the neighbourhood I M.
1785	Oct. 2 & 9	Italy, *Piedeluco*, Bonacquisto, Papigno and neighbouring towns in (Perugia) II B.
1785	Dec. 4	Mexico, Acapulco II Bo.
1785		Formosa, Hozan I H.
1786	Feb. 5	Greece, Corfu, 120 lives lost, Argos III M.
1786	Feb. 15	Transylvania, Klausenburg I M.
1786	Feb. 27	All over Upper Silesia, Poland, Hungary, Moravia, and Bohemia, from Brunn to Cracow, Schweechwitz I M.
1786	Mar. 9 & July 24	Italy, *Patti*, Naso, *Tindari* and other places in Messina, and also in Calabria III B.
1786	April 7	Italy, Milan, Monza, Bergamo and other places in (Lombardy) I B.
1786	June to July	China (Ssuchuan), Chungching Fu; (Yunnan), Tengyueh in Yungchang Fu I Ho.
1786	July to Oct.	Italy, *Lucoli*, and elsewhere in Aquila II B.
1786	July 26	China, Ili near Kuldja II Pa.
1786	Aug. 11	England, Cumberland and North Lancashire I M. & W.
1786	Nov. 24	Italy, Alba in (Cuneo) and adjacent towns I B.
1786	Dec. 3	Hungary and Silesia, Tarnowitz, Pless, Brieg, Ratibor, Leobschutz, Neisse I Ra.
1786	Dec. 23	China (Hunan), Yuanchiang, Lungyang, Changte in Changte Fu I Ho.
1786	Dec. 25	Italy, Rimini II B.
1786		U.S.A., Alaska, Pavloff, with volcanic eruption III F.R.
1786		Java, district of Batur, *Djampang* III M.
1787	Feb.	Chile, Castro I Mon.
1787	Mar. 23	Peru, Arequipa I Mon.
1787	Mar. 28-April 3	Mexico, centre near San Marcos, Acapulco, Ayutla, Igualapa, *Teotitlan* in Oaxaca, Michoacan and south to Tehuantepec; sea waves III O.B. & Bo.
1787	May 13	12th, 22h. G.M.T. Philippines, Panay Island, Provinces of (Iloilo and Antique), Buenavista II S.M.
1787	July 13	12th, 23h. G.M.T. Philippines, Panay Island, Provinces of (Iloilo, Capiz, Antique) and Guimaras III S.M.
1787	July 16-26	Italy, Ferrara I B.
1787	Oct. 1 & 21	West Indies, Jamaica, *Kingstown* and Port Royal I M.
1787	Dec. 26	Italy, Poppi (Arezzo) I B.
1788		Servia, Vranje, Mostanica, Ristobac III O.D.
1788	Spring	Asia Minor, Palu III M. & O.
1788	April 18	Italy, Fano in (Pesaro) I B.
1788	June to July	China (Yunnan), Tungchuan Fu I Ho.
1788	July 22	Aleutian Islands III M. & O.
1788	Oct. 12	West Indies, St. Lucia; 900 lives lost III M.
1788	Oct. 20	Italy, *Tolmezzo* (Udine), throughout (Friuli), Venice and Padua II M.
1788	End of Dec.	Hungary, Carlowitz II M.

A.D.		
1789	Jan. 19	Malta II O.D.
1789	May to June	China (Yunnan), Tunghai, Ning in Linan Fu, Chengchiang Fu I Ho.
1789	June 10	Iceland, Skalholt, Arnessysla, Tingvallavatn III M. & Th.
1789	Sept. 30	Italy, *Citta di Castello*, Selci, Cerbara, Lame and other places in (Perugia) III B.
1790	Mar. 18	Malta II M.
1790		Italy, Tolmezzo (Udine) II B.
1790	Mar. 21	Italy, Malta II B.
1790	April ?	Italy, Val di Noto, *Caltanisetta* (Messina) II B.
1790	April 6	The Bannet, all Transylvania, as far as Constantinople, *Roman*, *Jassy*, *Kaminieck*, *Bucharest* I M. M. & O. give III
1790	April 20	Mexico (Vera Cruz), *Cordoba*, Oaxaca and Mexico II O.B.
1790	May 19	Chile, Tucapel I Mon.
1790	July 26	Italy, Pontremoli (Massa) I B.
1790	Sept. 21	Venezuela, Caraccas I P.
1790	Oct. 8	South coast of Spain and North Africa, *Oran*, Carthagena, Malaga, *Santa Fé* and Malta II M.
1790 ?		U.S.A., California, Inyo County III F.R.
1791	Jan. 1	Japan, Tokio I O.
1791	Jan.	Italy, Aquila II B.
1791	April 15	Siberia, Nizhne-Kamtchatka II M. & O.
1791	May 16	U.S.A., Connecticut, Bridgeport and Hartford I F.R.
1791	Aug. 29	Hungary, Pressburg and the country round I M.
1791	Oct. 11	Italy, Foligno (Umbria) I B.
1791	Oct. 12	Italy, Monteleone and surrounding places III B.
1791	Oct. 13	Italy, Capri I B.
1791	Nov. 14	China (Shantung), Wenting, Jungcheng in Tengchou Fu I Ho.
1791	Nov. 2	Greece, Island of Zante; shocks continued six weeks III M. & P.
1791	Dec.	Canada, St. Paul's Bay in the St. Lawrence I M.
1792	Mar. 2	England, Leicester, Lincoln, Biggleswade, Bedfordshire I M. & W.
1792	Mar. 23	Japan (Hizen) II Mi.
1792	June 24	China (Kiangsu), Suchou, Chentse in Suchou Fu I Ho.
1792	July 20	Formosa, Kagi III H.
1792	July 20	Italy, Strettura in Spoleto I B.
1792	Aug. 23	Siberia, *Petropavlovsk*, *Nizhne-Kamtchatka*, *Paratunka* and all the east coast of *Kamtchatka* II M. & O.
1792		Chile, La Serena I Mon.
1793		Timor, Coepang II M.
1793		West Indies, St. Domingo II M.
1793	July 24-25	Italy, Ventottene, one of the Pontine Islands I B.
1793	Aug. 7	Chile, Arica I Mon.
1793	Sept. 28	England, Salisbury and Shaftesbury I M. & W.
1794	Feb. 6	Austria, Vienna, Styria, Brunn, and *Leoben*, *Gratz*, also in the Murzthal II M.
1794	Feb.	China (Yunnan), Tali I Ho.
1794	Mar. 14	Russia, Casan or Kasan III M.
1794	Mar. 26	Peru, Lima I H.J.
1794	May-June	China (Yunnan), Yiliang in Yunnan Fu III Ho.
1794	June 6 & 30	Italy, Tramonti, Socchieve, and other places in (Udine) II B.
1794	June 7	Austria, Trieste I B.
1794	June 12	Italy, Ariano (Avellino) I B.
1794	June 13-18	Italy, Portici, Resina and Naples, preceding an eruption of Vesuvius I B.
1794	Oct. 11	West Indies, Jamaica, Kingston I P.
1794	Nov. 25	Japan, Tokio I Mi.
1795	May 23	Mexico, *Oaxaca*, Puebla II O.B.
1795	Aug. 5	China (Chihli), *Luan* in Yungping Fu, Tungkuang in Hochien Fu III Ho.
1795	Aug. 15	Italy, San Gregorio in (Latium) I B.
1795	Aug.	Formosa, Kagi II H.
1796	Feb. 4 & 5	Italy, Florence and Arezzo I B.

A.D.		
1796	Feb. 26	Asia Minor, especially at Latakia; 1,500 perished III M.
1796	Mar. 18	Italy, Casamicciola (Ischia) II B.
1796	Mar. 30	Chile, Copiapo, Vallenar III Mon.
1796	Oct. 22	Italy, Ferrara, Medicina (Bologna) I B.
1796		Philippines. S. Luzon, Manila (Rizal) III S.M.
1797	Feb. 4	Ecuador, Quito, Riobamba, Latacunga, Ambato; 40,000 perished III M.
1797	Between Feb. 11 and Mar. 7	Philippines, Manila I S.M.
1797	Aug. 5	China (Chihli), Luan in Yungping Fu, Chi in Shuntien Fu III Ho. See 1795, Aug. 5.
1797	Aug.-Sept.	China (Yunnan), Shihping in Linan Fu I Ho.
1797	Dec. 4 & 11	Venezuela, *Cumana*, *Cariaco* and the surrounding country; 16,000 lives lost III M. & P.
1798	Feb. 2	Salvador, San Salvador, Cuscatlan III Mon.
1798	Mar. 14	France, Dept. of Meurthe, Sarreguemines, Bliastel, Bitche I M.
1798	May 23	Russia (Perm), Kungur and villages of Perm, Oka and Verkhoturie district I M. & O.
1798	May 26	Italy, Siena II B.
1798	July 8	Japan (Kaga) II O.
1798	Nov. 7	France, Bordeaux and the country round I M.
1799	Jan. 25	West coast of France at Rouen, Nantes, *La Vendée*, Bordeaux, Caen and in Jersey II M.
1799	Feb. 6	Guernsey I M. & W.
1799	Feb. 19	France, Avignon II M.
1799	Mar. 1	China (Shantung), Wenteng, Jungcheng in Tengchou Fu I Ho.
1799	May 29	Italy, Brescia, Cremona, Vicenza I B.
1799	June to July	China (Chihli), Yungping, Lanyu in Yungping Fu I Ho.
1799	July 28	Italy, Camerino, San Ginesio, Cessapalombo III B.
1799	Aug.-Sept.	China (Yunnan), Shihping in Linan Fu, Chiangchuan in Chengchiang Fu, Hsinping in Yuanchang I Ho.
1799, end of		Colombia and Venezuela, Cartago, Truxillo III Mon.
1800	Feb. 4	Colombia, Venezuela and Ecuador III O.D. Same as above?
1800	Feb. 26	Portugal, Lisbon I M.
1800	Mar. 8	Mexico, *Mexico City*, *Mixteca* in (Oaxaca), *Canada* in (Puebla), Morelos, Vera Cruz III O.B.
1800	Mar. 20-21	China (Chihli), Luan, Changli in Yungping Fu I Ho.
1800	Oct. 17	France, Eaux-Chaudes and some other places in the Valley of Ossau in the Pyrenees I M.
1800	Dec. 29	Italy, Valletri in (Latium) I B.
1801	Jan. 1	Chile, La Serena III Mon.
1801	July	Sweden, Eskilstuna in Sodermannland II M.
1801	Oct. 5	Mexico, Oaxaca III O.B.
1801	Oct. 8	Italy, Bologna I B.
1801	Beginning of December	Austria, Laibach in Carniola and *Eger* I M.
1801-2		Italy, Bardi in Piacenza I B.
1802	Jan 17	Spain, Torre de la Mata and Torrevieja I M.
1802	Feb.-Mar.	China (Yunnan), *Yunnan*, *Langchiung* in Tali Fu III Ho.
1802	May 12	Italy, *Soncino*, Gallignano, Romanengo and other towns in Brescia III B.
1802	Aug. 15	Venezuela, Cumana II P.
1802	Oct. 26	Austria, Hungary, Russia, and Turkey, *Bucharest*, *Constantinople* (Pera), Transylvania, Wallachia, Moldavia, *Hermannstadt*, Temeswar, Lemberg, Kief, Aral, Tula, *Moscow* and St. Petersburg II M. M. & O. give III
1802	Nov.-Dec.	China (Shantung), Chucheng in Chingchou Fu; (Kiangsi) Yutu, Kanchou Fu I Ho.
1802	Nov. 7	At and around Algiers, *Blidah* II M.
1802	Nov. 8	Germany, Strasburg and Weissemburg I M.
1802	Nov 26	Turkey, Constantinople, Galata and Pera I M.
1802	Dec. 28	Japan (Sado); sea waves III Mi.
1802		Aleutian Island II M. & O.
1803		Ecuador, New-Riobamba III R.S.

A.D.		
1803	Jan. 8	Poland, Bielostok, Grodno I M.
1803	Feb. 2	France, Marseilles I M.
1803	April 25	Japan, Tokio I O.
1803	Sept. 1	India, Calcutta, Barahal, Badrinath III Ol.
1803	Oct. 20	Caucasia, Tiflis I M.
1804	Feb.	Austria, Styria I M.
1804	June 8	Greece, St. Maura, Zante, *Patras* in the Morea II M.
1804	July 7	Japan (Ugo), Shonai III Mi.
1804	Aug. 25	Spain (Granada), Almeira and the surrounding district of Malaga and Carthagena. *Castel del Popolo*, or Castillo, *Enix*, *Dalias* and *Roquetas* II M.
1804	Sept. 16	Spain (Granada) I M.
1804	Oct. 11	Caucasia, Tiflis I M. & O.
1804	Oct. 18	Italy, Val d'Elsa in Siena I B.
1805	Mar. 21	Austria, Innsbruck I M.
1805	July 16	Colombia, Honda, Magdalenenstromes II O.D. R.S. gives III
1805	July 3	Greece, Island of Candia II B.
1805	July 26	Italy, Frosolone, Boiano, Vinchiaturo and throughout (Molise) and as far as Salerno and Naples III B.
1805	Aug.	China (Chihli), Luan in Yungping Fu; (Honan), Chiyuan in Huaiching Fu I Ho.
1805	Oct. 13	Italy, Nola, S. Maria di C. V. (Caserta) I B.
1806	Jan. 2-3	China (Kiangsi), Fengcheng in Nanchang Fu, Chian Fu, Huichang in Kanchou Fu II Ho.
1806	Feb. 12	Italy, Novellara, Correggio, etc. (Emilia) I B.
1806	Mar. 24	Midnight, U.S.A., California, Santa Barbara I F.R.
1806	Mar. 25-Apl. 3	Mexico, Zapotlan in Jalisco, *Colima*, Oaxaca, Michoacan, and the coast III O.B.
1806	Mar. & Nov.	Formosa, Shoka I H.
1806	April 9-10	Italy, Reggio and other places in (Calabria) I B.
1806	April 22	Siberia, Irkutsk I M. & O.
1806	June 19	Italy, coast of Nice I B.
1806	July 21	Italy, Montecassino (Caserta) I B.
1806	Aug. 8	Russia, Krasnoyarsk III M. & O.
1806	Aug. 26	Italy, Frascati, Genzano, Nami, Velletri in the hills of (Latium) II B.
1806	Nov.-Dec.	China (Kiangsi), Fuchou Fu, Kanchou Fu I Ho.
1806	Nov. 1	Spain, Granada II M.
1806		Salvador, San Salvador III Mon.
1806	Dec. 1	Peru, Lima I H.J.
1807	Jan. 22	China (Kansu), Chenyuan in Chingchou I Ho.
1807	Mar. 30	France, in the Northern part of the Puy-de-Dôme I M.
1807	Nov. 10	Italy, Tramutola, Saponara (Basilicata) I B.
1807	Nov. 18	Algiers II M.
1808	Feb.	Mexico, Acapulco (Guerrero) II O.B.
1808	April 2	Italy, Valli del Pellice and Chisone in Turin III B.
1808	April 13	India, Calcutta, *Chandernagore* I Ol.
1808	April 14 & 16	France and Switzerland, La Tour and Lucerne I M.
1808	May 17	Italy, Briquerasque or Bricherasio I M.
1808	Aug. 1	U.S.A., San Francisco, Upper California III O.B.
1808	Oct. 26	Italy, Leghorn I B.
1809	Mar. 10	Russia, Viatka and district I M. & O.
1809	April 5	Japan (Shinano) II Mi.
1809	April	Formosa, Shoka I H.
1809	May 3	Greece, Island of Corfu I M.
1809	July 30	China (Fukien), Hsinghua Fu III Ho.
1809	Aug. 7 & 8	China (Fukien), Hsinghua Fu III Ho. See above.
1809	Aug. 14	Italy, Aquila in the Abruzzi I B.
1809	Aug. 25	Italy, Macerata (Marches) II B.
1809	Winter	Italy, Rome, Montecompatri (Latium) I B.
1809		India (Gurhwal) I Ol.
1810	Jan. 14	Hungary, Stuhlweissenburg, the centre was apparently *Mt. Csoka* II M.
1810	Feb. 4	Japan (Sado) II Mi.
1810	Feb. 16	Greece, Island of *Candia*; 2,000 lives lost III M.
1810	Mar. 20 or 25	Canary Island and Island of Teneriffe III M.
1810	April 14	Hungary, Mur II M.
1810	Aug. 11	Azores, St. Miguel in St. Michaels, *Las Casas*; shocks until Jan. 1811 III M.

A.D.		
1810	Dec. 25	Italy, Novellara and other places in (Emilia) I B.
1810		Formosa, Tamsui I H.
1811		Greece, Zante I P.
1811	Feb. 18	Italy, Rome I B.
1811	Mar. 18	China (Fukien), Hsinghua III Ho. See 1809, July 30 and Aug. 7.
1811	May 30-Aug. 11	China (Shantung), Wenteng in Tengchou Fu II Ho.
1811	July 15	Italy, Appennines of (Modena) I B.
1811	Oct. 4	Austria, Styria, Carinthia, Krieglach in the Murz I Ra.
1811	Oct. 5	Philippines, S.E. Luzon (Camarines and Albay), Nueva Caceres, Albay III S.M.
1811	Dec. 16	U.S.A. (Mississippi, Ohio, Arkansas, Tennessee, Kentucky, Missouri, Indiana, Virginia, N. and S. Carolina, Georgia and Florida), *Vincennes*, *Cincinnati*, *Nashville*, *New Madrid*, Cairo II M. F.R. gives III The earthquake continued until 1813.
1812	Mar. 10	France, *Beaumont*, Vaucluse, Avignon, Apt and Marseilles II M.
1812	Mar. 22	Italy, Rome I B.
1812	Mar. 26	Venezuela and Colombia, Caraccas and the surrounding country, Varinas, Maracaibo, particularly in the high mountains of Mérida, Carthagena and in the Andes III M. & O.D.
1812	May. 1	South Wales, also Gloucester, Neath I M. & W.
1812	May 2	France, Nantes and a large part of Loire Inférieure I M.
1812	May 13	Germany, Zulpich near Cologne I M.
1812	May	U.S.A., Southern California I F.R.
1812	July 17	Germany, Kandern and Müllheim, in the Upper Breisgau I M.
1812	Sept. 11	Italy, Poppiano, S. Quirico and neighbourhood (Florence) I B.
1812	Sept. 15	Italy, Ischia and Naples I C.V.
1812	Oct. 8	U.S.A. (California). Santa Barbara, San Juan Capistrano II to III F.R.
1812	Oct. 21	U.S.A., California, San Juan Capistrano II F.R.
1812	Oct. 25	Italy, Treviso I B.
1812	Nov. 11	West Indies, Jamaica, Kingston II M.
1812	Dec. 7	Japan, Tokio, Kanagawa III Mi.
1812	Dec. 8	U.S.A., California, San Diego to Purisima I F.R.
1812		U.S.A. (Alaska), Atka III F.R.
1812	Dec. 21	U.S.A., California, San Fernando I F.R.
1813	Feb. 1 & 2	Roumania, Bucharest in Wallachia I M.
1813	May 30	Peru, Ica and Arequipa I Mon. H.J. gives II
1813	Sept. 21	Italy, *Faenza*, Forli and Imola (Emilia) I B.
1813	Sept. to Oct.	China (Kuangtung), Hsinhui, Hsiangshan in Kuangchou Fu I Ho.
1813 or 1815		U.S.A., California, Santa Clara Valley ? II F.R.
1813	Dec.	Greece, Epirus, Janina to Corfu, *Sorachovitzas* II M.
1814	Jan. 12	China (Kansu), Chanyuan in Chingchou I Ho.
1814	Feb. 1	Peru, Piura I H.J.
1814	Feb. 2	Philippines, S.E. Luzon (Albay) I S.M.
1814	April 3	Italy, Leghorn and Pisa I B.
1814	April 28	Austria, Innsbruck I M.
1814	June to July	China (Yunnan). Yun in Shunning Fu I Ho.
1814	Sept. 3	Siberia, Irkutsk, *Tunkinsk Fort* and surrounding villages III M. & O.
1814	Nov. 6	France, Lyons and from Macon to Vienne II M.
1814	Nov. 24	China (Fukien), Hsinghua III Ho.
1814	Dec. 17	Siberia, Irkutsk and felt as far as *Troitskosark*, 346 miles distant I M. & O.
1815	Jan. 2	Japan (Kaga) III O.
1815	May 3	Mexico (Oaxaca), Mexico State, Puebla and Vera Cruz II O.B.
1815	July	Formosa, Giran III H.
1815	Aug.	Italy, Pistoia I B.
1815	Aug. 5-6	China (Chihli), Tungkuang, Hochien Fu I Ho.
1815	Oct. 11	China (Fukien), Futing in Fuchou Fu III Ho.
1815	Oct. 14	Formosa, Tamsui II H.
1815	Oct. 21	China (Shensi), *Chishan* in Fenghsiang, Fuping in Hsian Fu; (Honan), Hsiuwu in Huaichang Fu III Ho.

A.D.		
1815	Oct. to Nov.	China (Kansu), Chenyuan in Chingchou I Ho.
1815	Nov. 16	China (Honan), Shenchou and other places III Pa. See above.
1816	May 26	India, Gungootri, Upper Valley of Ganges I Ol.
1816	Aug. 13	Scotland, Inverness I M. & W.
1816		Formosa, Guran II H.
1817	Jan.	Italy, Sciacca (Girgenti) I B.
1817	Mar. 18	N. Spain, Santander to Tarragona, *Riora* (Castille), Viscaya (Arragon, Catalonia), *Arnedo*, *Arnedillo* and *Logrono* II M.
1817	April	China, Changli on the borders of Szechuan ; 11,000 houses destroyed III M.
1817	April 4	Mexico, Oaxaca, Tlaxcala, Canada, Puebla and Vera Cruz I O.B.
1817	Oct. 5	U.S.A., Massachusetts, Woburn I F.R.
1818	Feb. 20	Italy, *Aciconsolazione*, Aci Platani and throughout (Catania) III B.
1818	Feb. 23	Italy, Nice, Portomaurizio, and Western (Liguria) I B.
1818	Feb. 23	France, Marseilles, Draguignan, Orelle in Savoy, Antibes and Vence II M.
1818	Feb. 28	Italy, Val di Noto (Messina) I B.
1818	May 31	Mexico, Mexico and eastwards to Vera Cruz, Morelos, Guerrero, Jalisco II O.B.
1818	Sept. 8	Italy, Petralia, Polizzi, and other places in the mountains of Le Madoine (Palermo) II B.
1818	Nov. 20	West Indies, Cap Henri in St. Domingo II M.
1818	Dec. 9	Italy, Parma, Reggio (Emilia), Modena, etc. I B.
1818		Philippines, N.W. Mindanao, Dapitan I S.M.
1819	Jan. 8	Italy, Port Maurizio, San Remo, and elsewhere in Western (Liguria) I B.
1819	Jan. 29	Caucasia, Tiflis I M. & O.
1819	Mar. 12	Mexico, *Orizaba* in Vera Cruz, Puebla I O.B.
1819	Mar.	Morocco, Oran and Mascara II M.
1819	April 3, 4, & 11	Chile, Copiapo III M. & Mon.
1819	May 3	Mexico, Oaxaca II O.B.
1819	May 26	Italy, Corneto (Latium) I B.
1819	June 16	India, Cutch and other parts of N. India, *Ahmedabad*, Poonah, and in *Bhooj* 2,000 perished III M. & Ol.
1819	Aug. 2	Japan, Kioto ; (Ise, Mino) III Mi.
1819	Aug. 31	Norway, especially at Saltdal and (Helgeland, Norland), *Hemnaes*, at Frosten and Drontheim I M.
1819	Nov. 29 to Dec. 3	China (Shantung), Huang in Tengchou Fu II Ho.
1820	Jan.	Hungary, Mur I M.
1820	Feb. 21	Greece, St. Maura II M.
1820	Mar. 7	Siberia, Irkutsk and around the *Turansk* frontier post I M. & O.
1820	May 4	Mexico, Acapulco, also *Chilapa*, *Mochitlan*, and other places in Guerrero, Oaxaca, Puebla, and Vera Cruz ; origin coast of Acapulco and S. Marcos III O.B. & B.O.
1820	Oct. 19	Honduras, Omoa, *St. Pedo* II M.
1820	Dec. 29	Greece, Morea and Ionian Isles, especially in *Zante* II M.
1820	Dec. 29	Chile, Coquimbo II M.
1821	Jan. 6	Greece, Zante, *Lala* in the Morea ; sea waves III M.
1821	Jan. 18	Chile, Valparaiso I Mon.
1821	Feb. 12	China (Chihli), Paoan in Hsuanhua I Ho. Also on Mar. 13 and Aug. 5.
1821	Mar. 21	Italy, Rieti (Umbria) I B.
1821	May 13	Mexico, Oaxaca, Puebla, Vera Cruz I O.B.
1821	July 10	5h. 42m., G.M.T. Peru, Arequipa, Camana III H.J. & Mon.
1821	Aug. 2 & Sept. 12	Italy, Catanzaro, Nicastro (Calabria) II B.
1821	Sept. 17	Moldavia, Jassy I - M.
1821	Nov. 17	Russia, Kief, Nikolaief, *Jassy* in Moldavia, Tiflis in Georgia I M.
1821	Nov. 22	Italy, Adriatic coast from Gargano to Termoli (Apulia) II B.

A.D.		
1821		Formosa, Unrin I H.
1821	Dec. 13	Japan (Izu) III O.
1822	Jan. to Feb.	China (Kiangsi), Kuanghsin Fu, Huchang in Kanchou Fu I Ho.
1822	Jan. 29	India, Madras, Chittore, Vellore I Ol.
1822	Feb. 7	Japan, Oshiu, Tokio III Mi.
1822	Feb. 19	Italy, Chambery (Savoy) I B.
1822	April 6-10	Italy, Nicosia and neighbourhood (Catania) I B.
1822	May 7	Costa Rica, Carthago III M. & O.D.
1822	June 21	China (Fukien), Hsinghua III Ho.
1822	July 14	Italy, Belvedere, Umbriatico, Cotrone in Catanzaro I B.
1822	July 29	Spain, Granada I M.
1822	Aug. 13	Asia Minor, Aleppo, *Antioch*, *Latakia*, and *Djesr-Darjua*, Beyrout, Alexandria III M.
1822	Sept. 5	Asia Minor, Aleppo, Damascus, and the Island of Cyprus; altogether 20,000 lives were lost III M.
1822	Nov. 1 & 5	Chile, *Copiapo* and Coquimbo III M. & P. Mon. gives II
1822	Nov. 20 & 25	3h. 1m., G.M.T., 20th. Chile, Argentina, Concepcion, Mendoza, San Juan, *Valparaiso*, *Melipilla*, *Quillotoa*, *Mepel*, *Casabianca*, Santiago; earthquake extended from Copiapo to Valdivia 900 miles; coast elevated along a length of 100 miles; sea waves III M., P. & Mon.
1822	Dec. 1	West Indies, Island of Grenada I M.
1823	Jan. 10	Spain (Murcia and Valentia), Orihuela, Carthagena and Alicante II M.
1823	Feb.-Mar.	Formosa I Ho.
1823	Mar. 5	Italy, *Naso*. Palermo and North coast of Sicily III B.
1823	May 7	Central America, Panama, *Cartago*. Monkey Point, North of Greytown, Darien III Mon.
1823	June 19	Turkey, Souli ? I M.
1823	Aug. 25	Asia Minor, Scala-Nova, West of Smyrna II M.
1823	Nov. 17	China (Fukien), Hsinghua Fu III Ho.
1824	Jan .	Philippines, E. Luzon, along eastern mountain range (Sierra Madre), and Southern Caraballo II S.M.
1824	Feb. 21	Greece, Ionian Island, Island of St. Maura I M.
1824	April 10	West Indies, Jamaica, Kingston I P.
1824	April 20	West Indies, Island of St. Thomas I M.
1824	June 23	Persia, *Shiraz* and *Kazrun* III M.
1824	July-Aug.	China (Kuangtung), Kuangchou Fu I Ho.
1824	Aug. 12	Italy, Selvapiana and neighbourhood (Romagna) I B.
1824	Sept. 29	Philippines, East part of S. Luzon (Tayabas, Rizal, Laguna and Nueva Ecija) III S.M.
1824	Oct. 26	Philippines, S. Luzon, Manila, and neighbouring provinces III S.M.
1824	Dec. 10-11	Italy, *Rossano*, Corigliano and Longobucco (Cosenza) II B.
1825	Jan. 18 & 21	Iceland, Reykjavik II Th.
1825	Jan. 19	Greece, Island of St. Maura, Ionian Isles and *Prevesa* in Albania III M.
1825	Jan. 24	Mexico, Oaxaca I O.B.
1825	Mar. 2	Algiers and the country lying towards the Canary Islands, *Blidah* III M.
1825	April	Philippines, Guam Island in the Ladrones Island II S.M.
1825	Sept. 20	West Indies, Trinidad II P. & O.D.
1825	October	Persia, Shiraz II M.
1825	Oct. 27	Italy, Isernia (Campobasso) I B.
1825	Dec. 5	China (Hunan), Changsha Fu, Linwu in Kueiyang, Hengchou Fu, Yungchou Fu II Ho.
1826	Jan. 26	Albania, Prevesa I M.
1826	Feb. 1	Italy, *Tito*, Sasso, Pietrafesa and elsewhere in the (Basilicata) II B.
1826	May 17	Spain, Granada I M.
1826	June 17	Colombia, Santa Fé-de-Bogota III M.
1826	Aug. 18	West Indies, Jamaica, Montego Bay I M.
1826	Sept. 18	West Indies, Cuba, Santiago II P.
1826	Oct. 26	Italy, Manduria (Lecce) I B.
1826	Oct. 29	India, Nepal, Katmandu, Patun II Ol.
1827	Jan. 16	China (Fukien), Hsinghua III Ho.

A.D.		
1827	Feb.-Mar.	China (Hupeh), Yunyang I Ho.
1827	April 11	Italy, Ischia I C.V.
1827	April 17	Austria, Croatia, Karlstadt I F.
1827	May	Siberia, Kirensk in Irkutsk Govt. and in Petropavlovsk village, 53 miles from Kirensk I M. & O.
1827	May 30	Peru, Lima II M.
1827	June 12	Mexico, Tehuacan II M.
1827	June	Behring Sea, Commander Islands III M. & O.
1827	June or July	Asia Minor, Tokat III M.
1827	Aug. 7	U.S.A. (Indiana), New Albany on the Ohio I M.
1827	Sept.	Formosa, Shoka I H.
1827	Before Sept. 26	India, Fort Kohtaran near Lahore; 1,000 perished III M. & Ol.
1827	Oct. 21-23	Caucasia, Tiflis, Stavropol I M. & O.
1827	Nov. 16	Colombia, Santa Fe-de-Bogota to Pasto, *Neiva*, *Popayan*, *Parace*, Valley of Magdalena, Bogota III M. & O.D.
1827	Nov. 30	West Indies, Islands of *Martinique*, Guadeloupe, Marie Galante, Antigua, St. Domingo II M.
1827	Dec. 13	Portugal, Lisbon I M.
1828	Feb. 2	Italy, Island of Ischia II B.
1828	Feb. 4	Mexico (Tabasco), and *Villa Hormosa* III M.
1828	Feb. 19	Iceland, Fljotshlid and Landeyjar; many farms fell II Th.
1828	Mar. 7-19	Siberia, Irkutsk, Troitskosavsk, Kiakhta, Turansk frontier post III M. & O.
1828	Mar. 12	Italy, Palmi (Reggio di Calabria) I B.
1828	March	Mexico, Tacotalpa (Tabasco) I O.B.
1828	Mar. 30	Peru, Arequipa, Huanuco, Truxillo, *Lima*, *Callao* II M. & H.J.
1828	April	Italy, Meldola, Galeata, Bertinoro (Romagna) I B.
1828	April 11 or 14	Italy, Urbino I B.
1828	May 18	Italy, Marsala (Trapani) I B.
1828	June 6	India, Cashmir; 1,000 killed III Ol.
1828	June 15	Asia Minor, Smyrna I M.
1828	Aug. 9	Caucasia, Shusha, *All-Shemaka*, *Mugaly* III M. M. & O. give Aug. 14.
1828	Aug.-Sept.	China (Chihli), Wuchiao, Tungkuang in Hochien Fu I Ho.
1828	Sept. 14 & 15	Spain (Murcia, Valencia), *Lorca*, *Orihuela*, *Torrevieja*, *La Mata*, *Guardamar* II M.
1828	Oct. 1	Canary Islands, Island of Gran-Canaria I M.
1828	Oct. 5-8	Italy, Forli (Emilia) I B.
1828	Oct. 9	Italy (Voghera and Bobbio), north of Genoa II B.
1828	Oct. 29	India, Nepal, *Katmandu*, *Patna* II M.
1828	Nov. 9	10h. 30m., G.M.T., Philippines, S. Luzon, Manila and neighbouring provinces II S.M.
1828	Nov. 16	6.30 p.m., Colombia, Bogota, Pasto, Popayan III O.D.
1828	Dec. 18	Japan (Echigo); sea waves at Kiushu III Mi.
1828	Dec. 29	Celebes, Macassar, *Boelekomba* with sea waves II M.
1829	May-June	Italy, Albano and other places in (Latium) I B.
1829	Feb. 21	Throughout the South of Iceland and near *Hecla* II M. & Th.
1829	Mar. 8	Siberia, Irkutsk from Kiachta to Nizhni-Udinsk, Troitskosarsk I M.
1829	Mar. 21	Spain (Murcia, Valencia), Valley of the Segura, Guardamar, *La Mata*, *Torrevieja* III M.
1829	May 5	Turkey, coast of Macedonia and Thrace, *Salonica* to Constantinople, *Drama*, *Kawala* and *Seres* III M.
1829	May 23	Turkey, Constantinople and Scutari I M.
1829	Aug. 4	Hungary, especially at *Nagy-Karoly*, *Endred*, *Dengeley*, *Zriny* and *Portelek* II M.
1829	Sept. 6	Italy, Cremona I B.
1829	Sept. 26	19h. 12m., G.M.T., Chile, *Valparaiso*, *Santiago*, and *Casa Blanca* I P. & Mon. M. gives Oct. 26.
1829	Oct. 1	Chile, Santiago I Mon.
1829	Nov. 18	China (Anhui), *Wuho* in Ssuchou; (Shantung), Chining; (Kiangsu), Shuchou Fu III Ho.
1829	Nov. 19	China (Shantung), *Linchu* in Chingchou Fu, Tengchou Fu, Laichou Fu; (Chihli), Tiensin III Ho.

A.D.		
1829	Nov. 24	China (Shantung), Changching in Chinan Fu III Ho.
1829	Nov. 26	S.W. Russia, Roumania, from Transylvania to Kief, Bucharest, *Kishinev*, *Reni*, *Tiraspol* and *Cherson* III M.
1829	Nov. 30	Siberia, Barnaul and Suzun Smelting Works I M. & O.
1830	Jan. 18	9h., G.M.T. Philippines, S. Luzon (Rizal, Tayabas, Laguna, Cavite, Batangas), *Manila* III S.M.
1830	Jan.	Mexico, Oaxaca, Canada, and Mixteca I O.B.
1830	Mar. 9	Caucasia, Kizlar on the Terek, Mozdak, Ekaterinodar, and still more violently in the village of *Andreief*, also felt at Tiflis, Fort Bournoi, *Tarki* III M. also M. & O.
1830	April 12	Guatemala, the villages of *Amatitlan*, *Pinula* and *Petassa* or *Petapa* III M.
1830	April 14	West Indies, St. Domingo I P.
1830	April 23	Guatemala III M. Continuation of April 12.
1830	May 9	Persia, Teheran I M.
1830	May 12-22	China (Chihli), Paoting Fu, Shunte Fu, Tiensin Fu; (Shantung), Chinan II Ho.
1830	May-June	China (Kiangsu), Hsuchou Fu; (Chihli), Paoting Fu I Ho.
1830	June 1	China (Chihli), Chengting Fu III Ho.
1830	June 8	Austria, Styria, Semmering I Ra.
1830	June 12, also June 16 & July 29	China (Chihli), Hokien Fu, Kaichou in Taming Fu; (Honan), Nanyang Fu; also (Shantung, Anhui, and Kiangsu) III Ho. See entries from May 12.
1830	June 25	Caucasia, Unezapnaya, 18°10N. 46°40E. II M. & O.
1830	June 26	Austria, Styria, Murztal, Leoben, Bruck, Graz I Ra.
1830	July 1	Hungary, Huszt, Maramarosch Sziget and the mines of Sugatagh and Slatina I M.
1830	Aug. 19	Japan, Kioto III Mi.
1830	Dec. 1	Russia, *Anapa* and Taman Peninsula I M. & O.
1830	Dec. 31	India, Chittagong I Ol.
1831	Jan. 2	Italy, Lagonegro, Lauria in the (Basilicata) II B.
1831	Jan.-Feb.	Italy, Milazzo (Messina) I B.
1831	Feb. 23 & 27	China (Chihli), Paoan in Hsuanhua Fu I Ho.
1831	May 19	Siberia, *Turkinsk* mineral springs, near Lake Baikal I M. & O.
1831	May 26	Italy, Castellare, S. Remo and elsewhere on the coast of (Liguria) II B.
1831	June-July	Italy, Sciacca (Girgenti) II B.
1831	Aug. 11	West Indies, Bridgetown in Barbadoes and in Jamaica, especially at Antigua, St. Vincent, Dominica, Guadeloupe and Barbadoes; also hurricane III M. & P.
1831	Sept.-Oct.	China (Kiangsu), Kiangning Fu, Hsuchou Fu, Chenchiang; (Anhui), Ssuchou II Ho.
1831	Sept. 11	Italy, *Reggio* (Emilia), Parma and Modena I B.
1831	Oct. 9	2h. 16m., G.M.T. Peru, Arica, Arequipa II H.J. & Mon.
1831	Nov. 13	Japan, Kioto: (Hizen) II Mi.
1831	Dec. 3	West Indies, Trinidad, St. Christopher II P.
1831-32	Oct.-Feb.	Italy, *Foligno* and other towns in (Perugia) II B.
1831		India, Peshawar and Valley of Indus I Ol.
1832	Jan. 22	Central Asia, Bokhara, Kokand, Badakshan and Upper Oxus III M. & O.
1832	Feb. 21	Italy, Pozzuoli and neighbourhood of Naples I B.
1832	Feb. 21	N.W. India, Lahore, Valley of Badakshan III Ol.
1832	Mar. 8	Italy, Valley of the *Tacina* and other parts of Cotrone and adjacent parts of (Calabria) III B.
1832	Mar. 13	Italy, *Reggio* (Emilia), Modena, Parma II B.
1832	Nov. 24	Italy, Nicolosi, Belpasso, Milo and near Etna II B.
1832	Nov.	Formosa, Giran III H.
1833	Jan. 19	Italy, Monteparano (Lecce) I B.
1833		West Indies, Antigua, St. Kitts II O.D.
1833	April 25	15h. 16m., G.M.T. Chile (Coquimbo), Huasco II Mon. & P.
1833	Aug. 26	India, Nepal, Calcutta, Agra, Lucknow, Tirhoot, Purneah, Patna, Buxar, Allahabad, Monghyr, *Katmandu* and Lhasa III M. & Ol.

A.D.		
1833	Sept. 6	China (Yunnan), *Yunnan Fu*, *Linan Fu*, *Chengchiang Fu*, *Chuching Fu* and all (Yunnan); it continued Nov. to Dec. III Ho.
1833	Sept. 18	10h. 31m., G.M.T. Peru and Chile, Arequipa, Arica and Tacna II Mon. & H.J.
1833	Dec. 4	Mexico, Oaxaca, Vera Cruz, Puebla and Guerrero I O.B.
1833	Dec. 7	Japan (Sado); sea waves II O.
1833	Dec.	Formosa II H.
1834	Jan. 22	Peru, past St. Marthe III P.
1834	Feb. 14	Italy, Pontremoli, *Alberelo* and elsewhere in (Massa) II B.
1834	Feb.	Russia, Anapa, Bugas and shore of Abasia I M. & O.
1834	Feb.	Japan, Yezo (Ishikari) III Mi.
1834	May	Philippines, Guam Island in the Ladrones III S.M.
1834	May 16	Japan (Suruga, Kai) II Mi.
1834	May 23	Asia Minor, Palestine, Jerusalem I M.
1834	June 18	Greece, Island of Cephalonia II M.
1834	July 10-22	China (Honan), Changte Fu, especially in the district of Wungang, westwards to (Shansi), northwards to (Chihli), and east to (Shantung) III M. & O. O. gives June 28 to July 10; not in list by Ho.
1834	July	Chile, Ica, no details ? I Mon.
1834	Oct. 4	Italy, Bologna I B.
1835	Jan. 6	Mexico, *Acapulco* III M. Not given by Bo. or O.B.
1835	Feb. 6	Italy, *Vicchio*, Mugello (Tuscany) I B.
1835	Feb. 20	16h. 26m., G.M.T. Chile, Santiago, *Concepcion*, *Talcahuano* and *Chillan*; the earthquake was felt from Copiapo to Chiloe, and from Juan Fernandez to Mendosa; sea waves III M., Mon. & P.
1835	Feb. 26	Colombia, Venezuela, Haiti III O.D.
1835	Mar. 23	Italy, Boves (Cuneo) I B.
1835	April 11	Behring Sea, Pribylof Islands III M. & O.
1835	April 21	Russia, Bessarabia and Bucharest I M. & O.
1835	July 20	Russia (Livonia), Lemberg I M. & O.
1835	Aug. 19	Japan (Mutsu, Nemuro); sea waves III O.
1835	Aug. 23	Asia Minor, *Kaisarich* and the surrounding country, *Kumetri* III M.
1835	Oct. 12	Italy, *Castiglione*, S. Pietro in Guarano, Zumpano and other places in (Cosenza) III B.
1836	Jan. 5	Philippines, Mindanao Islands, *Illana Bay* (Zamboanga, *Cotabato*) I S.M.
1836	Jan. 24	India, Chandernagore, Sook-Sagur, also Kabul I Ol.
1836	April 2	U.S.A., Alaska, Pribyloff Islands III F.R.
1836	April 24	Italy, *Rossano*, Crosio, Cropalate and other places in (Cosenza) III B.
1836	May 3-4	Italy, Reggio (Calabria) I B.
1836	June 12	Italy, Liedolo, Fonte, S. Ilaria, Asolo (Venetia) II B.
1836	July 3, June ?	13h. 16m., G.M.T. Chile, Cobija; sea waves I Mon.
1836	July 8	Italy, Craco (Basilicata) I B.
1836	Aug.	U.S.A., Alaska, Pribyloff Islands III F.R.
1836	Aug. 30	Mexico, Oaxaca I O.B.
1836	Nov. 20	Italy, Lagonegro (Basilicata), Montesano in (Salerno) and other places II B.
1837	Jan. 1	Asia Minor, Syria, from Beyrout, *Damascus* to *Sahpit*, *Jaffa*, *Acre*, *Tiberias*, *Rani* near Cana III M.
1837	Mar. 14	Austria, Styria, Semmering in Murz, Reichman, Ebriechsdorf I Ra.
1837	Mar. 18	Greece, *Hydra*, *Spezia*, *Paros*, and Santorin, the centre was at Methana II M.
1837	April 11	Italy, *Uglian Caldo*, Argigliano, Montefiore and other places in the Alpi Apriane (Tuscany) II B.
1837	April-May	Italy, *Villa*, S. Germano, Montecassino (Caserta) I B.
1837	Aug. 2	West Indies, St. Thomas I O.D. & P.
1837	Sept. 6	West Indies, Barbadoes I P.
1837	Nov. 7	12h. 51m., G.M.T. Chile, *Valdivia* III M.
1837	Nov. 22	Mexico, Acapulco (Mexico), *Oaxaca*, Puebla, Tlaxcala, Vera Cruz, Querctaro, San Luis Potosi, Michoacan, Jalisco, Colima, Guerrero III O.B. Bo. gives I
1838	Jan. 23	S.W. Russia (Wallachia, Moldavia, Transylvania, Hungary) and Balkan Peninsula III M. & O.

A.D.		
1838	Feb. 14	Italy, Foligno, Spoleto and neighbourhood in (Umbria) I B.
1838	Mar. 17	England, Shrewsbury I M.
1838	May 22	France, Meandre in the Isère I M.
1838	June 11 & 12	Iceland, north coast, Hunafloi, Skajalfandi, Southland, Eyrarbakki III Th.
1838	June 23	Italy, Pessaro (Marches) I B.
1838-9		Italy, S. Jean de Maurienne and other places in the Valley of the Arc (Savoy) I B.
1839	Jan. to Feb.	China (Yunnan), Tengchuan in Tali Fu, Langchiung III Ho.
1839	Feb. to Mar.	China (Kiangsi), Pengtsa in Chuchiang Fu I Ho.
1839	Jan. 11	West Indies, Island of Martinique, also in Guadeloupe and St. Lucia II M. & O.D.
1839	Jan. 17	Turkey, Salonica I M.
1839	Jan. 21	West Indies, St. Lucia, Martinique I P.
1839	Mar. 22	Salvador, San Salvador III Mon.
1839	Mar. 23	India (Burmah), Amarapoora, Ava III Ol.
1839	June 10	Peru, Ica I H.J.
1839	June 28 & 29	Russia, Village of Fedorovka, Saratof Government II M. & O.
1839	Aug. 11 & 16	France, Annecy in (Savoy) I M.
1839	Aug. 18	Siberia, Irkutsk and along the Selenga River III M. & O.
1839	Aug. 27 & in 1840	Italy, Reggio (Calabria) I B.
1839	Oct. 1-10	Salvador, San Salvador II Mon.
1839	Oct. 12	China (Kiangsu), Changchou Fu; (Chehkiang), Chiahsing Fu I Ho.
1839	Oct. 23	Scotland, Comrie, Perthshire I M. & W.
1839	Oct. 29	China (Chehkiang), Huchou Fu; (Kiangsu), Chentse in Suchou Fu, Chingpu in Sungchiang Fu, Chenchiang Fu II Ho.
1840	Jan. 5	France, in the Pyrenees I M.
1840	May to June	China (Chehkiang), Wuning in Nanchang Fu; (Hupeh), Kuangchi in Huachou Fu I Ho.
1840	June 20-28	Armenia, the whole district of Mount Ararat II M.
1840	July 2	Armenia, Depts. of Surmalu, Sharum 39°15N. 45°E. and *Nakhichevan* 39°12N. 45°20E., Talysh, Ordubat district III M. & O.
1840	July 6 & 8	Armenia, district of Mount Ararat III M.
1840	July 27	Armenia, Ararat and Shahriar III M. & O. See July 2. This and the three preceding entries may be components of one megaseism.
1840	Aug. 27	Austria, Karlstadt, Laibach, Agram I F.
1840	Oct. 28	Greece, Island of Zante, Skulikado III M.
1840	Nov. 20	Armenia, Nakhichevan and the neighbouring districts, more violent in *Shahriar* II M.
1840	Nov.	Formosa, Unrin III H.
1840		Philippines, S.E. Luzon (Sorsogon and Masbate) III S.M.
1841		Italy, Reggio (Calabria) II B.
1841	Feb. 10	Mexico, Isthmus of Tehuantepec, Oaxaca II O.B.
1841	Feb. 21-22	Italy, San Marco in Lamis and other places in (Foggia) II B.
1841	Mar. 6	Italy, Casamicciola (Ischia) I B.
1841	Mar. 20	Italy, Lipari Islands I B.
1841	April 3	Denmark (Jutland) and (Schleswig Holstein) II M.
1841	April 21	Scotland (Argyle), Oban I M. & W.
1841	April 30	Hungary, Sea of Marmora to Altendorf in Galicia, *Menhard* and *Tatra* I M.
1841	May 18	Armenia, Village of Kibrakh 39°24N. 45°9E., also in Nakhichevan III M. & O. M. gives May 5.
1841	May 18	Russia, Petropavlosk and Ostrowneje II M. & O.
1841	May	Japan (Suruga) II O.
1841	June 8-9	Italy, Torre Passeri in the (Abruzzi) I B.
1841	June 10	Italy, Taranta, Tarricelli, and Palena in (Chieti) II B.
1841	June 14 & 15	Azores, Island of Terceira II M.
1841	July 13	Austria, Vienna, more severe at *Neustadt*, slight at Gratz I M.
1841	July 30	Scotland (Perthshire) I M. & W.

A.D.		
1841	Sept. 2	6 a.m. local. Costa Rica, Cartago, *Turodo*, *Tres-rios*, *Parowso*, *Ujamès*, *Matina*, San Jose to Heredia and Alajuela ; also strongly felt in the U.S.A. III O.D.
1841	Sept. 22	Armenia, Nakhchevan and neighbourhood I M. & O.
1841	Oct. 15	Italy, Sanguinetto and neighbourhood in (Verona) I B.
1841	Oct. 23	Hungary, Comorn II M.
1841	Oct. 24	Germany, Cologne I M.
1841	Dec. 2	France (Savoy), Chambéry I B.
1841	Dec. 25	Armenia, Anapa, Nikolaievsk and Vitaz I M. & O.
1812	Jan. 2	Caucasia, Baku and neighbouring villages III M. & O.
1842	Jan. 11	China (Kiangsu), Sungchiang Fu, Tanyung in Chenchiang Fu ; (Chehkiang), Chiahsing Fu I Ho.
1842	Feb. 19	North-west India, Kabul, Jellalabad, Peshawar III Ol.
1842	May 7	West Indies, St. Domingo, especially at Cape Haytien, also at Jamaica, Porto-Rico, and almost all the West Indian Isles II M.
1842	Sept. 9	Hungary (Zala), Gross-Kanischa or Nagg-Kanisa I M.
1842	Nov. to Dec.	China (Kiangsu), Tanyang in Chenchiang Fu ; (Hunan), Liuyang in Changsha I Ho.
1842	Dec. 1	Algiers I M.
1843	Jan. 4	U.S.A., Illinois, Cairo I D.
1843	Jan. 5-6	Sumatra, S.E. coast of Baros and Island of Nias ; sea waves II P.
1843	Feb. 8	West Indies, Guadeloupe, Pointe à Pitre, St. Lucia, St. Kitts, Antigua, Montserrat, Martinique III F.R., O.D. & P.
1843	Mar. 28	France (Meurthe), Luéville I P.
1843	April 1	India, Bombay, Sholapur in the (Deccan) III Ol.
1843	April 6	Holland, Vechel I P.
1843	April 25	Japan, Yezo (Kushiro, Nemuro), sea waves III O.
1813	June 23	U.S.A., California I P.
1843	July 25	Hungary, Temeswar I P.
1843	Sept. 26	Italy, Ragusa I P.
1843	Oct. 2	Russia (Bessarabia, Podolia), Balta, Sorok, Odessa I M. & O.
1843	Oct. 18	Asia Minor, Karki near Rhodes III P.
1843	Oct. 25-27	Italy, *Barberino*, Verino and other places near Mugello in (Tuscany) I B.
1843	Oct. 26	Asia Minor, Erzeroum II P.
1848	Dec. 17	21h. 56m. or 23h., 1m. G.M.T. Chile, La Serena I Mon.
1844	Mar. 10	Italy, Forli I B.
1844	May 12	Persia, Ispahan, Julpha, Azerbaijan and Irak III P.
1844	May	Turkey, Angora, Osmandjik II P.
1844	May	Nicaragua, Greytown II Mon.
1844	June 3-4	France, Poitiers I P.
1844	July 17	Italy, Palestrina (Latium) I B.
1844	Aug.	Nicaragua, San Juan II Mon. & P.
1844	Aug. 30	West Indies, St. Vincent, Grenada, British Guiana, Trinidad II P.
1844	Sept. to Oct.	China (Yunnan), Chengchiang Fu I Ho.
1844	Oct. 6	China (Shantung), Ninghai in Tengchou Fu III Ho.
1844	Oct. 18	5h. 18m. G.M.T., Argentina, *Jujui*, *Salta*, *Tucuman* III Mon.
1844	Dec. 2	China (Kiangsu), Chiangyin in Changchou Fu, Paoshan, Chiating in Taitsangchou, Sungchiang Fu ; (Chehkiang), Chiashing Fu II Ho.
1844	Dec. 3	Norway, Kongsvinger, Eideskog I P.
1844	Nov. 4	Hungary, Szigeth near Buda I P.
1845	Feb. 8	Celebes, Menado III P.
1845	Feb. 12	Abyssinia (Gondor) between Lake Tana and Damot Bay, 6-12°N. 33-36°E. I P.
1845	Mar. 5	Java, Buitenzorg I P.
1845	Mar. 9	Mexico, *Oaxaca*, Puebla, also Atlantic and Pacific coasts III O.B.
1845	April 7	Mexico, Acapulco, Xochimilco in (Mexico), Puebla, Tlaxacalla, Vera Cruz, Queretaro, San Luis-Potosi, and in the West, Central coast of Acapulco or S. Marcos III O.B., Bo. & P.
1845	April 19-25	India (Cutch), Lakhpat I Ol.
1845	May 23	Spain (Teruel) I P.

A.D.		
1845	May 24	Russia, Akhaltzikhe and district II M. & O.
1845	June 4	3h. 1m., G.M.T. Chile, Tacna and Arica I Mon.
1845	June 19	India, Delta of the Indus, Lakhpat II P.
1845	July 10-11	Italy, Matera in the (Basilicata) I B.
1845	July 21-25	Moluccas, Amboina I P.
1845	Aug. 6	India (Assam), *Gowhatty*, *Sylhet*, Serampore, Midnapore I Ol.
1845	Sept. 2 to May, 1847	Iceland, eruption of Hecla and many shocks I Th.
1845	Sept.	China (Kansu), Chenyuan in Chingchou I Ho.
1845	Oct. 7	Spain, Tivisa, Vandellos, Pratdip I P.
1845	Oct. 15	Greece, Priscia, Acras, Ayasso, Mételin II P.
1845	Oct. 21	China (Kiangsu), Chingkiang in Changchou Fu III Ho.
1845	Dec. 17	West Indies, Guadeloupe, Pointe a Pitre I P.
1845	Dec. 19	Austria, Laibach I P.
1845	Dec. 21	Austria, Laibach in Carniola I B.
1846	Jan. 11	Armenia, Nakhichevan I M. & O.
1846	Jan. 25	Moluccas, Ternate with sea waves I P.
1846	Feb. 19	Colombia, River Madeleine and Rio Lagunilla I P.
1846	Mar. 14-15	Norway, Naunstad near Christiania
1846	Mar. 28	Crete, Canéa, Candia II P.
1846	Mar. 28	Malta and Gozo and felt as far as Naples, destructive in Crete I B. & P.
1846	April 23	Russia, Javarisi or Dshwari, Kutais Government II M. & O.
1846	June 8-10	Greece, *Mitylene*, Kalamata, Nisi III P.
1846	June 21	Asia Minor, Smyrna II P.
1846	July 4	China (Chehkiang), *Haiyen*, Pinghu in Chenhsing Fu; (Kiangsu), Suchou Fu, Hsuchou Fu III Ho.
1846	July 29	Germany, Ems, Aix-la-Chapelle, Siegbourg, Bonn, Boppart I P.
1846	Aug. 3	China (Shangtung), *Ninghai*, *Huang* in Kengchou Fu; (Kiangsu), Suchou Fu, Sungchiang Fu; (Chehkiang), Huchou Fu III Ho.
1846	Aug. 4	China (Kiangsu), *Chiating*, Paosan, Chungming in Taitsangchou, Sungchiang Fu; (Shantung), Chingchou Fu; (Chehkiang), Ningpo Fu III Ho.
1846	Aug. 5	China (Kiangsu), *Sungchiang*, Nanhui in Sungchiang Fu. Severe shocks on Aug. 7, 10, 14, 18 and 27 III Ho.
1846	Aug. to Sept.	China (Kiangsu), *Yihsing*, *Chingchi* in Changchou Fu, Sungchiang Fu. Shocks until Dec. 29 III Ho.
1846	Aug. 7	Italy, Syracuse II B.
1846	Aug. 8-9	Italy, Campomaggiore, Craco and other places in the (Basilicata) I B.
1846	Aug. 12	Lucques ? I P.
1846	Aug. 14	Italy, Orciano, Luciana, Monte Scudaio and elsewhere in the Pisan Hills III B.
1846	Aug. 17	Switzerland, Lausanne, Yverdon I P.
1846	Aug. 18	Siberia, *Irkutsk* and Kirensk I M. & O.
1846	Sept. 13	West Indies, Trinidad, St. Domingo I P.
1846	Oct. 18	India, *Momansingh*, Calcutta, Serampore I Ol.
1846	Nov. 1	Algiers, Cherchell I P.
1846	Nov. 21	Algiers, Cherchell I P.
1846	Dec. 24	Java, Penggalengan I P.
1847		Egypt, Cairo I O.D.
1847	Jan. 19	15h. 30m., G.M.T. Chile, Copiapo II P. Mon. gives I
1847	Jan. 25	France, Vendée, Lucon I P.
1847	Feb. 8 ?	Chile, Copiapo II P.
1847	April 7	Germany, Nuremberg, Coburg, Eisfeld I P.
1847	May	Peru, Huancarama and Carabaya II P. & H.J.
1847	May 8	Japan (Shinano), *Zenkoji*; (Echigo) III Mi.
1847	May 13	Siam, Chantabun I P.
1847	May 15 or 16	Russia, Kushwinsk, Verkhoturie, Nizhneturie and Bisersk mines and works in the Urals I M. & O.
1847	June 18	Algeria, Douera, Koubah I P.
1847	June 28	Peru, Ica II P.
1847	July 24	China (Kiangsu), Taitsangchou, Sungchiang Fu; (Chehkiang), Ningpo Fu I Ho.
1847	July 28	Spain, Seville, Jean, *Badajoz* I P.

A.D.		
1847	July 31	Nicaragua, St. Jean III P.
1847	Aug. 7	Egypt, Cairo, Alexandria II P.
1847	Sept. 5	West Indies, Dominica II P.
1847	Sept. 11	Sweden, Helsingborg III P.
1847	Oct. 2	Mexico, Mexico and *Ocotlan*, *Guadalajara*, Oaxaca, Puebla III P. & O.B.
1847	Oct. 8	16h. 46m., G.M.T., Chile, *Liguai*, *Petorca*, Valparaiso, Santiago, *Coquimbo*, *Atacama* and *La Serena* III P. & Mon.
1847	Oct. 17	Chile, Coquimbo, Illapel, Ligua I-II Mon.
1847	Oct. 23	Mexico, Atlixco III P. See Oct. 2.
1847	Oct. 31	N.W. Sumatra, between Great and Small Nicobars II P.
1847	Nov. 12	China (Kiangsu), Taitsangchou, Suchou Fu, Sungchiang Fu: (Chehkiang), Ningpo Fu; (Kiangsi), Kanchou Fu II Ho.
1847	Nov. 16	Java and S.E. Sumatra, Chéribon (Palimanan, Rembang, Semarang and Lampong) III P.
1847	Dec. 20	Russia, Tiflis I P.
1847	Dec. 20	Portugal, Sabserra II P.
1847	Dec. 27	Spain (Alava), Orduna and (Delica) I P.
1847	Dec.	Mexico, Colima, Zapotlan II P.
1847		U.S.A., Alaskan Coast, *Sitka* II F.R.
1848	Jan. 1	Nova Scotia, Lawrence Town I P.
1848	Jan. 1	West Indies, St. Lucia I P.
1848	Jan. 11	Italy, Augusta, Noto, Syracuse, Catania, etc. II B.
1848	Feb. 16	Java, Batavia, Semarang II P.
1848	Feb. 11	Morocco I P.
1848	March 1-2	Germany, Oppenheim I P.
1848	April 29	Morocco, Melilla I P.
1848	May 13	Siam, Chantabun I P.
1848	May 31	Mexico, *Guadalajara* in (Jalisco), Guerrero, Oaxaca, Mexico, Puebla II O.B.
1848	June	Italy, Montagnolo in (Siena) I B.
1848	July 5	Italy, Ventotene in Pontine Islands I B.
1848	July 19	Spain (Aragon), Torres I P.
1848	July 27 to Aug. 7	Java, Bantam I P.
1848	Sept. 9	West Indies, St. Lucia I P.
1848	Sept. 24	Caucasia, Shemaka I P.
1848	Oct. 16-25	New Zealand, Wellington, *Nelson*, Wanganui, with sea waves II P. O.D. gives Oct. 17.
1848	Oct. 27	Central America, *E. Nicaragua*, also felt in Honduras and Salvador I P. & Mon.
1848		Formosa, Unrin III H.
1848	Dec. 31	Azores II P.
1848-50		Bolivia, Santa Cruz de la Sierra II Mon.
1849	Jan. 6	Italy, Mascheta and Casetta di Tiara in (Tuscany) I B.
1849	Jan. 24	Austria, Vienna I P.
1849	Jan. 25	6h. 56m., G.M.T. Philippines, Ladrones Islands, Guam Island, Bay of Umata, Agana III P. & S.M.
1849	Jan. 29	Siberia, Government of (Tobolsk) at Ishim I P.
1849	Feb. 25	Marianne Islands III P.
1849	April 9	Argentina, San Luis III Mon.
1849	May 3	Venezuela, Maracaibo I P.
1849	May 28	Moluccas, Island of Amboina, Island of Honimoa, *Saparoea* I P.
1849	June 12	Azores, Praya de Victoria II P.
1849	June or July	West Indies, St. Domingo I P.
1849	June 17	Chile, La Serena; sea waves I Mon.
1849	Aug. 20	Austria, Weiss-Passung, Glognitz, Wiesser I P.
1849	Oct. 22	U.S.A., Alaska, Commander Islands II-III P. & F.R.
1849	Nov. 28	Italy, Borgotaro (Parma) I B.
1849	Dec. 17	Chile, Coquimbo, Santiago and Valparaiso; sea waves I Mon.
1849		Philippines, S.W. Guam II F.R. Not in S.M.
1850	Jan. 1	Italy, Biancavilla and Belpasso (Catania) II B.
1850	Feb. 9	Algiers I P.
1850	April 3	Asia Minor, Smyrna, Nymphio I P.
1850	July 15	Austria (Bohemia), Elbogen, also Morea, Vostizza I P.
1850	Aug. 17	Sweden (Skaraborg), Werlingen, Danstrop I P.

A.D.		
1850	Aug. 19	Austria (Dalmatia), Stagno, Piccolo I P.
1850	Sept. 18	Italy, Modena I B.
1850	Sept. 22	China (Ssuchuan), Sichang III Pa.
1850	Oct. 7 & 8	Moluccas, Amboina I P.
1850	Nov. 8	Malta I B.
1850	Nov. 11	Italy, S. Nicandro (Aquila) I B.
1850	Nov. 20	France, Lourdes, St. Pé I P.
1850	Dec. 6	11h. 26m., G.M.T. Chile, *Santiago*, from Coquimbo to Talca, 310 miles II P. & Mon.
1850	Dec. 17	Algeria, Guelma, Bone I P.
1851	Feb. 2	Colombia, Carthagena II P.
1851	Feb. 5	Austria (Tyrol), Switzerland I P.
1851	Feb. 7	Colombia, Carthagena II P.
1851	Feb. 20-22	West Indies, Porto Rico I P.
1851	Feb. 25	Asia Minor (Anatolia, Trebisond), Samsun I P.
1851	Feb. 28	Asia Minor (Anatolia), Makri, *Rhodes* III P.
1851	Mar. 18	6.45 a.m., local, Costa Rica, San José, Heredia, Barba, *Alajuela*, *Cartago* and *Guanacasti* II P., O.D. & Mon.
1851	Mar. 24	West Indies, Costa Rica, Alajuela III P.
1851	April 2	11h. 27m., G.M.T. Chile, *Valparaiso*, *Casa Blanca*, on the road to Sanitago, extended north to Copiapo, Coquimbo and Cobija and south to Concepcion III P.
1851	April 11	Italy, Messina I B.
1851	April 13	Armenia, Nakhichevan I M. & O.
1851	April 13	Sweden, Gothenburg, Lysekil, and Laegeland I P.
1851	April 13	Austria (Herzegovina) ; Stagno, Piccolo I P.
1851	April 19	Baluchistan, Gwador I Ol.
1851	May 15	Spain, Majorca Island II P.
1851	May 16	West Indies, Guadeloupe, Basse-Terre I P.
1851	May 17	Guatemala (Quetzaltenango) III P.
1851	May 26	Chile, Copiapo, Huasco, Vallenar and Freirana with sea waves II P. & Mon.
1851	June 27	Austria, Salzburg, Reichenhall I P.
1851	July	Hungary, Comorn I P.
1851	July 30	Austria, Roveredo, Tione I P.
1851	Aug. 14	Italy, *Melfi*, Rionero, Barile, Rapolla in (Basilicata) III B.
1851	Aug. 24	Switzerland, Unterwald I P.
1851	Sept. 1	Austria, Stagno, Piccolo I P.
1851	Sept. 6 & 7	Italy (Apulia), Conosa I B.
1851	Oct. 12	Turkey in Europe, Albania, Valona, Beratti, Elbassen II P.
1851	Nov. 14	Honduras, Tegucigalpa II Mon.
1851	Nov. 28	Siberia, Okhotsk Dept. along coast of the sea of Okhotsk from the Taui to the Tuman post, 470 miles II M. & O.
1851	Dec. 1	West Indies, Pointe-à-Pitre I P.
1851	Dec. 27	Russia, Gelabuga (Wjatka) I P.
1851-2	April to Jan.	Italy, Tresilico (Reggio-di-Calabria) I B.
1852	Jan.	Austria, Karlstadt, Agram I F.
1852	Jan. 24	India, Upper Sind, Murree Hills III Ol.
1852	Jan. 24	Mexico, *Soyaltepec* and elsewhere in Oaxaca I O.B.
1852	Jan. 25	Spain (Catalonia), Olot I P.
1852	Jan. 26	France (Gironde), Libourne I P.
1852	Feb. 22	France (Ariège), Massat I P.
1852	Feb. 22	Central Asia, Derbent I P.
1852	April 16	Azores, St. Michel II P.
1852	May 26	China (Kansu), Chungweihien III Pa.
1852	May	India, Darjiling II Ol.
1852	June 7	Italy, Ischia I O.V.
1852	July 7	West Indies, Jamaica I P.
1852	July 7	Italy, Ischia, Casamicciola I O.V.
1852	July 8	Asia Minor, Rhodes, Makri, Levisi I P.
1852	July 24	Armenia, Erzerum III M. & O.
1852	Aug. 20	14h. 5m., G.M.T. West Indies, Cuba, Santiago III P. & O.D.
1852	Aug. 23	Germany, Würtemberg, Biberach II P.
1852	Aug. 20	Asia Minor, Erzerum II P.
1852	Aug. 26	Greece and Turkey, Ramazau II P.

A.D.		
1852	Aug.	Eyorsura III P.
1852	Sept. 16	10h. 45m., G.M.T. Philippines, S. Luzon (Zamballo, Pampanga), Manila, (Cavite and Batangas) II S.M.
1852	Sept. 25	Philippines (Camarines and Albay) I S.M.
1852	Oct. 15	Java, Keboeman, (Poerworedjo) I P.
1852	Nov. 4	Mexico, Acapulco III P.
1852	Nov. 9	U.S.A., Arizona, Fort Yuma I or II F.R.
1852	Nov. 20	France (Drôme), Dieu-le-Fit I P.
1852	Nov. 20	Java, Semarang, Dagelin, Kadae I P.
1852	Nov. 26	Moluccas, Great Banda, Loathoir, Papenberg, Neira; with sea waves III P.
1852	Nov. 26	8h. 37m., G.M.T. West Indies, Cuba, Santiago, Sierra Maestra II P., O.D.
1852	Dec. 4	Mexico, Acapulco, Ayutla, origin near *San Marcos* I Bo.
1852	Dec. 17	U.S.A., California, San Luis, Obispo I P.
1852	Dec. 20-21	West Java III P.
1852	Dec. 24	Batavia, Buitenzorg I P.
1852	Dec. 24	Philippines, S. Luzon (Batangas) II S.M.
1853	Jan. 1	New Zealand, New Plymouth I P.
1853	Jan. 12	Sweden, Arbra and Unders-Vik I P.
1853	Jan. 18	Armenia, Delishan, Village of Chubukhly, Tiflis district and Sevanga Island II M. & O.
1853	Jan. 20	Java, Sampang I P.
1853	Jan. 27	Spain, Barcelona I P.
1853	Jan. 30	Italy, Ischia, Casamicciola I C.V.
1853	Feb. 9	Salvador and Guatemala, La Antigua, Amatitlan, Quezaltenango I P.
1853	Feb. 19	Italy, Amara (Friuli) I B.
1853	Mar. 11	Japan, Odawara (Sagami, Suruga, Izu, Mikawa, Totomi) I Mi.
1853	Mar. 12	U.S.A., North part of State of New York I P.
1853	Mar. 18	Armenia, Ssabui near Zarskije-Kolodzy I P.
1853	April 1	France, Normandy, Granville and throughout Coutances I P.
1853	April 4	Salvador, San Salvador I P.
1853	April 12	Moluccas, Hila, Laricke I P.
1853	April 13	China, Shanghai, village 30 miles from Shanghai completely ruined II M. & O. P. gives April 14.
1853	April 18	Switzerland (Grisons), Coire or Chur I P.
1853	April 19	Italy, *Caposele*, Teora, Leone, Calabritto in (Avellino) II B.
1853	April 21-22	Persia, Shiraz; 12,000 people killed III P.
1853	June 2	Persia, Jusd, Fort Umachan-Jusd damaged I P.
1853	June 14	Austria, Karlstadt, Agram I F.
1853	July 11	Persia, Ispahan, 10,000 people killed III P.
1853	July 15	Venezuela, Cumana, 800 or 4,000 people killed III P.
1853	July 14	Costa Rica, Canas Gordas, Bagaces II P.
1853	Aug. 2	Italy, Pomarance, Volterra in (Tuscany) I B.
1853	Aug. 11	Switzerland, south of Soleure and Biberist I P.
1853	Aug. 15	Venezuela, Cumana I P.
1853	Aug. 18	Greece (Bœotia), Thebes, and bounded on north by M. Atalante, east by Gulf of Atalante, south by R. Asopus, west by L. Copais III P.
1853	Aug. 26	Guatemala, Trujillo I P.
1853	Sept. 22	Italy, Spoleto in (Perugia) I B.
1853	Sept. 30	Greece, Athens, Chalcis, Island of Scyros and Tenedos, Bagaces II Mon. P. gives Aug. 24 and Sept. 10.
1853	Oct. 10	Austria (Herzogovina), Mostar I P.
1853	Nov. 30	Java, District Glawoe I P.
1853	Early in Dec.	Turkey, Constantinople I P.
1853		Philippines, S.E. Luzon (Camarines), Nueva Caceres, Daet II S.M.
1853		Formosa, Tamsui I H.
1854	Jan. 2	Mexico, Durango I O.B.
1854	Jan. 13	Spain (Andalusia), Finana I P.
1854	Jan. 13	Mexico, San Juan del Rio and *Tlalpujahua* in (Queretaro) I O.B.
1854	Jan. 14	23h. 56m., G.M.T., Chile, Coquimbo I P. & Mon.
1854	Feb. 12	Italy, Donnici, S. Ippolito, Torzano and other places in (Cosenza) II B.

A.D.		
1854	Feb. 15 & 21	Abysinia, Betalihem near Mahdara I P.
1854	Feb.	Peru or Venezuela, Truxillo I P.
1854	Mar. 12	Turkey, Constantinople I P.
1854	Mar. 17	West Indies, Cuba, Santiago I P.
1854	April 15	Guatemala and Salvador III P. & Mon.
1854	May 3	Java, Residence of Kediri, Prigi I P.
1854	May 5	Mexico, *Cordoba* in Vera Cruz, Acapulco, *Oaxaca*, Puebla, Mexico II O.B.
1854	May 15	Algeria, Blidah I P.
1854	June 11	Salvador, San Vicente I P. & Mon.
1854	June 16	Italy, Imola in (Romagna) I B.
1854	July 9	Japan (Yamashiro, Yamato, Kawachi, Izumi, Settsu, Omi, Tamba, Kii, Owari, Iga, Ise, Echizen) III O.
1854	July 14-17	Guatemala, Amatitlan, Escuintla II P. & Mon.
1854	July 30	Turkey, Albania, Fortress of Suli I P.
1854	July 31	France, Bagnères, Grip, Argelès, Tarbes, Eaux-Bonnes, Cauterets I P.
1854	Aug. 29	Java, Padang I P.
1854	Sept. 23	Persia, Tabriz II P.
1854	Sept. 28 or Oct. 3	China, Hongkong, Canton I P.
1854	Oct. 1	Persia and Caucasia (Ghilan), Resht, Enzeli and Shemaka I P.
1854	Nov. 26	Salvador, San Salvador I P.
1854	Dec.	Moluccas, Banda I P.
1854	Dec. 23 & 24	All Japan, but chiefly central at and near Tokio, Shikoku, (Suruga, Totomi, Mikawa, Ise, Iga, Inaba); sea waves III O.
1854	Dec. 29	France and Italy, Grasse, Cagnes, Var, Saint Paul, Menton, Ventimiglia, Bordighera, S. Remo and other places in Western (Liguria) I P. & B.
1855	Jan. 23	New Zealand, Wellington, Wairau, Wanganui, Otaki III P. & O.D.
1855	Jan. 24	U.S.A., California, Downieville, Gibsonville, Georgetown I P.
1855	Jan. 26-27	Italy, Macchia and surrounding places near Etna I B.
1855	Jan.	Guatemala, Quetzaltenango I P.
1855	Feb. 1	Mexico, Vera Cruz, Jalapa, Chilpancingo, Oaxaca, Puebla I O.B. P. gives II
1855	Feb. 5	Algeria, Ouennoupha, Mélouza II P.
1855	Feb. 9	New Zealand, Wellington I P.
1855	Feb. 14	New Zealand, Wellington II P.
1855	Feb. 17	Greece, Samos I P.
1855	Feb. 28	Turkey and Asia Minor, Adrianople, Dardanelles, Gallipoli, *Brussa*, Smyrna II P.
1855	Mar. 2	Asia Minor, Smyrna, *Macri* II P.
1855	Mar. 5-6	Asia Minor, Brussa I P.
1855	Mar. 8	Mexico, Oaxaca, especially *Mixteca* II O.B.
1855	Mar. 22	Philippines, S. and S.E. Luzon (Tayabas, Camarines, Albay, Sorsogon) I S.M.
1855	March	Guatemala, Quezaltinango I P.
1855	April 11	Turkey, Asia Minor, Brussa, Constantinople I P.
1855	April 25	Moluccas, Ternate, Halmahera II P.
1855	April 25	Panama, Aspinwall, Gatun I P.
1855	April 27	Norway, Kinservig I P.
1855	April 29	Asia Minor, Brussa to Mouhalitch near Mount Olympus III P.
1855	June 26	Java, Tjilatjap I P.
1855	July 3	Turkey, Albania, Scutari II P.
1855	July 10	U.S.A., California, Los Angeles, St. Bernardino, Santa Barbara II P.
1855	July 14	Moluccas, Halmahera, Ternate, Tidore II P.
1855	July 25 to Dec.	France, Germany, Italy and Switzerland, Viège, all the east of France, *Visp* in the Valais (Piedmont) and in the Lower Rhine to Strassburg II P. & B.
1855	Aug. 14	Turkey, Albania, Scutari, Vaudens, Bouchat, Jubani, Zadrima, Kosmatchi, in Drin Valley II P.
1855	Aug. 22	Switzerland, Valais, Ausserberg I P.
1855	Oct. 22	New Zealand, Taranaki I P.
1855	Nov. 8	Malta I P.

A.D.		
1855	Nov. 11	Spain, Granada I P.
1855	Nov. 11	Japan, Tokio; (Sagami, Shimosa) III Mi.
1855	Nov. 23	France, Basses Alps, Castellane I P.
1855	Dec. 5	France (Haute-Garonne), Chaum, from Tarbes to Auch I P.
1855	Dec. 5	Celebes, Gorontalo I P.
1855	Dec. 6	Spain, Barcelona I P.
1855	Dec. 12	France, Basses Alps, Castellane II P.
1856	Jan. 12	Portugal (Algarve), Soulé, Faro, Albufeira and Tavira II P.
1856	Jan. 19	Java, Semarang I P.
1856	Feb. 2	Mexico, Oaxaca, Canada I O.B
1856	Feb. 4	Switzerland, Valley of Visp. Toerbel I P.
1856	Feb. 12	Ecuador, Latacunga (Chimborazo), Cuença, Banos and (Quito) II P. R.S. gives III
1856	Feb. 16	U.S.A., California, San Francisco, it extended from Santa Rosa to Monterey, 143 miles I P.
1856	Feb. 17	Asia Minor, Brussa II P.
1856	Feb. 22	Turkey, Constantinople, Samsun, Varna III P.
1856	April 7	India, Kangara, Simla, *Kotghur* I Ol.
1856	May 5	Honduras, Belize, Omoa I P.
1856	May 11-12	Italy, Acquaviva, Canosa and elsewhere in (Bari) I B.
1856	May 23	Siberia, Selenginsk I P.
1856	June 5	Italy, Pieve S. Steffano in (Arezzo) I B.
1856	July 23	Caucasia, Shemaka III P., M. & O.
1856	Aug. 4	Honduras, Omoa, San José III P. & Mon.
1856	Aug. 6	Celebes, Gorontalo I P.
1856	Aug. 14-17	China, southern part of (Chihli), Yuching, 20 miles from Pekin destroyed III P., M. & O.
1856	Aug. 21	Algeria, Bone, Philippeville I P.
1856	Aug. 23	Japan, Hakodate II O.
1856	Sept. 2	Algeria, Djidjelli I P.
1856	Oct. 2	Algeria, Philippeville I P.
1856	Oct. 9	Spain, Murcia I P.
1856	Oct. 12	Mediterranean, Malta, Gozo, Civita Vecchia, *Karpathos*, Palermo, Corfu, *Rhodes*, Candia, Cassos, Simi and Castelloriso III P., B. & O.D.
1856	Oct. 12 or 22	Grecian Archipelago, Santorin, Stalchi, Carpentes, Cossos; shocks reached Syria and Egypt I P.
1856	Oct. 26	Java near Papandajang I P.
1856	Nov. 4	Japan, Tokio I Mi.
1856	Nov. 9	Austria, Laibach I P.
1856	December	Salvador, San Salvador, Jaltepeque II P.
1856	Dec. 6	Siberia, Selenginsk I P.
1856	Dec. 25	India, Bombay. Sirat I P.
1857	Jan. 8 & 9	U.S.A., Southern California, *Santa-Clara*, Santa-Barbara, Los Angeles, Monterey, Stockton III P. & F.R.
1857	Jan. 24	France (Nord), Cambrai, Brotteaux I P.
1857	Jan. 27	Sumatra, Benkoolen I P.
1857	Feb. 1	Italy, *Parma*, Casalmaggiore and Modena, etc. I B.
1857	Feb. 25	Celebes, Gorontalo I P.
1857	Mar. 7	Austria, Laibach I P.
1857	Mar. 7	Italy, Lubiana in (Venetia) I B.
1857	Mar. 12	Loochoo Islands, Naha I P.
1857	Mar. 29	Hungary, Homonna I P.
1857	April 6	Moluccas, Banda Island, Neara I P.
1857	April 9	Asia Minor (Bitlis), Kinnis, Mush II P.
1857	April 17	New Guinea, Rook Island or Umbon Island I P.
1857	May 13	Timor, Dilly, Kambing, Atapoepoe II P.
1857	May 21	Asia Minor, Brussa I P.
1857	May 24	Sumatra, Padang I P.
1857	May 27	Celebes, Gorontalo I P.
1857	June 14	Japan (Suruga) II O.
1857	Aug. 14	Cape of Good Hope I P.
1857	Aug. 19	Mexico, *Yautepec* in Morelos, Oaxaca, Puebla, Tlaxcala I O.B.
1857	Aug. 20	Peru, Piura I P.
1857	Sept. 17	Turkey, Brussa and at the same time at Péra near Constantinople I P.
1857	Oct. 8	U.S.A. (Illinois), Centralia I P.

A.D.		
1857	Oct. 15	Japan (Iyo) II O.
1857	Oct. 27 ?	Persia, Tesong, Azerbaidjan II P.
1857	Nov. 5	Salvador, Guatemala, San Salvador I P.
1857	Nov. 10	Switzerland, Como, Menaggio I P.
1857	Nov. 24	Austria, Spital, Windisch-Garsten I P.
1857	Nov. ? Dec. 27	Asia Minor, Brussa I P.
1857	Dec. 16	Italy (Basilicata), Salerno III B.
1857	Dec.	Salvador, San Salvador, Cajutepeque III P.
1857	Dec.	Uganda, Gondokoro on the Nile I P.
1857	Dec. 24	Siberia, Semipalatinsk Prov. and Tomsk Govt., especially *Kokpetinsk* and *Ust-Kameinogorsk* I P., M. & O.
1858	Jan. 6	Loochoo, Naha I P.
1858	Jan. 6	Italy, Castellucio Inferiore in the (Basilicata) I B.
1858	Jan. 15	Hungary (Moravia and Gallicia), *Mintzchow*, *Visnyove* I P.
1858	Feb. 21	Greece, Athens, Kalamaki and Corinth I P.
1858	Feb. 24	West Indies, Martinique, St. Pierre I P.
1858	Feb. 27	Moluccas, Ternate I P.
1858	Mar. 9	Algiers, Blidah, Milianah, Boujarik and Cherchel I P.
1858	April 9	Japan (Etchu, Echizen) II O.
1858	April 13	Austria, Carinthia, Rosegg I P.
1858	April 19	Asia Minor, Brussa I P.
1858	April 23	Japan (Shinano) II O.
1858	April 24	Guatemala, Amatitlan, Escuintla, as far as Salvador, Cojutepeque I P.
1858	April 30	Austria, Pola and Citena I P.
1858	Early in May	Nicaragua, Granada and Masaya II P. & Mon.
1858	May 2	Mexico, Oaxaca, Puebla, Vera Cruz, Guerrero and Chiapas I O.B.
1858	May 24	France and Germany, Mayence, Oppenheim, Wiesbaden I P.
1858	June 4	Moluccas, Ternate, Manado and Bachian in Celebes Islands I P.
1858	June 19	Mexico (Mexico), Puebla, Tlaxcala, *Patzcuaro* in (Michoacan), San Luis-Potosi (Jalisco, Colima and Guerrero) III P. & O.B.
1858	July or Aug.	Ecuador, Quito III P.
1858	Aug. 11	India, Simla I Ol.
1858	Aug. 24	North of British Burmah, Thayet-myo, Prome, Akyab, Khyouk-Phyoo ; origin between Irawadi and Bay of Bengal II Ol.
1858	Aug. 28	Peru, Amotape, R. Chira I P.
1858	Sept. 20 to Oct. 10	Turkey and Greece, Corfu, *Epirus*, *S. Albania* (Delwino), Kutsch, Schulat, Fuschabarda III P.
1858	Oct. 3	Algeria, Aumale I P.
1858	Oct. 9	Turkey and Greece, Albania, Valona, Gimave, Drymades, also Epirus I P.
1858	Oct. 10	Italy, Brindisi I B.
1858	Oct. 16	France (Vosges), Saut-de-la-Cuve I P.
1858	Oct. 25	France, Pignerols, Cavour I P.
1858	Oct. to Nov.	Italy, Pinerolo (Turin) I B.
1858	Nov. 9	Moluccas, Amboina I P.
1858	Nov. 11	Portugal and Spain, Lisbon, Cintra, Mafra, Belem, Setuval, Seville II P.
1858	Nov. 26	U.S.A., California, San José I P.
1858	Nov. 28	Bosnia and Albania (Zwarnick), Tuzla, Ergheni II P.
1858	Nov. 29	France (Basses Pyrénées), Mauléon I P.
1858	Dec. 13	Celebes, Ternate I P.
1858	Dec. 23	West Indies, Jamaica, Kingston I P.
1858		Philippines, Mindanao, Lanao and Cotabato I S.M.
1859	Jan. 9	Asia Minor, Erzerum I P.
1859	Jan. 20	Italy, Collalto (Treviso) I B.
1859	Jan. 22	Ecuador, Quito and between Guayaquil to Popayan III P.
1859	Mar. 5	France, Basses-Pyrénées, St. Jean-le-Vieux I P.
1859	Mar. 22	Ecuador, Quito, Machachi, Perucho, Pomasqui, Saint Antonio, Chillogallo ; felt from Guayaquil to Magdolena and Popayan in Colombia III P.
1859	April 10	Peru, Callao I P.

A.D.		
1859	April 12	Italy, Osservanza, Colombaio and neighbourhood in (Siena) I B.
1859	May 21 or June 2	Asia Minor, Erzerum, origin in Palentjukan Mountains and Erlidag III P.
1859	May 31 or June 12	Caucasia, Shemaka, Baskal, Zourmel, Lagitch I P.
1859	June 26	Caucasia, Shemaka and Erzerum I M. & O. This, May 21 and June 12, form one group.
1859	July 13	Armenia, Tiflis and Erzerum I P., M. & O.
1859	July 29	Celebes, Menado ; sea waves I P.
1859	Aug. 20	Turkey, Island of Imbros, *Panaya*, Ayotheodoro, Pyrgos (Gallipoli, Dardanelles) II P.
1859	Aug. 22	Italy, Norcia, and surrounding country in (Perugia) II B.
1859	Aug. 25-Sept. 3	Salvador, La Union ; sea waves II P. & Mon.
1859	Aug. 31	Turkey, Sophia, Tchoadjikhan, Chirvan in Tiflis II P.
1859	Oct. 5	12h. 46m., G.M.T. Chile, *Caldera*, *Copiapo* II P.
1859	Oct. 5	U.S.A., California, San Francisco I P.
1859	Oct. 6	Mexico, Canada and elsewhere in Oaxaca II O.B.
1859	Oct. 8	Moluccas (Halmaheira), *Kao*, Ternate II P.
1859	Oct. 11	Chile, Copiapo II P.
1859	Nov. 9	China (Shingking), Kaichou, Newchuang II Pa.
1859	Dec. 1	U.S.A., California, San Francisco I P.
1859	Dec. 8	Central America, *Guatemala*, *Nicaragua*, *Tepecoya*, *Guayamoco*, *Panchimalco*, Nahuizalco, *San Silvestre*, *Izalco*, *San Martin*, Masahuat, Nahulango, Juayua, Santo Domingo, San Antonio, Caluco, Acajulta ; sea waves II P.
1860	Jan. 18	Guatemala, Antigua, Escuintla II P.
1860	Feb. 1	France, Pyrenees, Rocheblanche I P.
1860	Feb. 6	Austria, Bosnia, Travnik I P.
1860	April 8	West Indies, Haiti, Port-au-prince, l'Anse au Veau, Cayes, Acquin II P.
1860	April 18	Peru, Arequipa I H.J.
1860	April 22	Peru, Lima, *Callao*, Chorillos, Manta, Lurin, Carabayllo, Huauhipa II P. H.J. gives I
1860	May 8	Austria, Styria, Rann I P.
1860	May 16	Turkey, Albania, Berzita near to Tirano I P.
1860	May 27 or 30	Italy, Norcia (Perugia) I B.
1860	June 7	Asia Minor, near Mt. Olympus I P.
1860	June 21-24	Central America, Tepalitai, Vera Cruz, Guadaloupe, Guatemala, Cojutepeque, Santa Maria, Ostuma II P.
1860	July 19	Italy, Callalto, Guia (Treviso) I B.
1860	Aug. 5	Nubia, Berber I P.
1860	Sept. 20	Bolivia, Chile, Paz, *Tacna* I P. & Mon.
1860	Sept. 20	Iceland, Reykjavik I Th.
1860	Sept. 27	Algeria, Bordj-Bou-Arreridji, *Takmat*, l'Oued-Sahel, Tensaout II P.
1860	Sept. 28	Lower Austria, Litschau I P.
1860	Oct. 3-6	Salvador, San Salvador II P.
1860	Oct. 13	Celebes, Minahassa I P.
1860	Oct. 17	U.S.A. and Canada, N.E. New England and State New York, *Baie-St.-Pauls*, Rivière-Ouelle I P.
1860	Nov. 4	Caucasia, Belii-Kliuch, 41°33N. 44°30E. I M. & O. See Nov. 9.
1860	Nov. 9	Caucasia, Nazran II P. See Nov. 4 and 28.
1860	Nov. 28	Caucasia, Nazran I P. See Nov. 9.
1860	Nov.	Formosa, Tamsui I H.
1860	Dec. 2	Asia Minor, Smyrna, Chio, Kutaiah I P.
1860	Dec. 3	Central America, Guatemala, San Salvador, Santiago, Santa Tecla, Quezaltepeque, Opico, Tacachico III P.
1860	Dec. 3	Armenia, Erzerum I P.
1861	Jan. 28	Italy, S. Sofia (Tuscany) I B.
1861	Feb. 9	Italy and Malta I B.
1861	Feb. 16	S.W. Sumatra, Padang (Acheen), Batu Island, Nias Island ; sea waves III P.
1861	Feb. 16	Sunday Islands II M. & O.
1861	Feb. 22	Behring Sea, Copper Island I M. & O.
1861	Mar. 5	Caucasia, Shemaka I M. & O.

A.D.		
1861	Mar. 9	Sumatra, Padang, Islands of Batu, Simo III P.
1861	Mar. 16	Italy, Varese, Ligure (Liguria) I B.
1861	Mar. 21	0h. 16m., G.M.T. Argentina, *San Luis*, *San Vicenti*, Lujan, Mendoza, reached Santiago in Chile III P. & Mon.
1861	Mar. 29	Algeria, Blidah I P.
1861	April 13	Peru, *Ayacucho* and all the Province of (Andahuailas) III P. & H.J.
1861	April 27	West Indies, Jamaica, Montego Bay, Kingston II P.
1861	April 27	Algeria (Constantine), Biskra I P.
1861	May 9	Italy, Citta della Pieve, Cetona and other places in (Perugia) II B.
1861	May 24	Caucasia, Shusha, *Sardob*, Shemaka II P.
1861	June 5	Java (Krawang), Pakis; sea waves I P.
1861	July 3	U.S.A., California, San Francisco, Valley of Amador, *Oakland* I P.
1861	July 10	Sumatra, Benkoelen I P.
1861	July 12	Canada, *Ottawa*, Montreal I P.
1861	July 31	India, Benares II P. Not given by Ol.
1861	Aug. 3-6	Guatemala, Antigua, Jalpatagua I P. & Mon.
1861	Aug. 21	Philippines, Manila I P. Not given by S.M.
1861	Aug. 23	Guatemala, *La Antigua*, Amatitlan, San José I Mon.
1861	Aug. 26	India, Benares I P. Not given by Ol.
1861	Aug. 27	Guatemala, *Conguaco*, *Jalpatagua* (Jutiapa) I P.
1861	Aug. 29	Argentina, San Carlos I Mon.
1861	Sept. 25	Sumatra, Padang, Indrapoera with sea waves I P.
1861	Oct. 16	Italy, Forli I B.
1861	Oct. 17	Spain, Alicante I P.
1861	Nov. 19-28	Italy, Potenza (Basilicata) I B.
1861	Dec. 9	Italy, Torre del Greco, Resina and Naples, near Vesuvius I B. & P.
1861	Dec. 17	Caucasia, Alkan-yhurt 42°18N. 45°E., Samashs I M. & O.
1861	Dec. 18	Austria, Croatia I P.
1861	Dec. 26	Greece, Corinth, Aigion. Vostizza, Galaxidi II P.
1861		Formosa, Toroku II H.
1862	Jan. 1	Greece, Athens, Patras, Aigion or Vostizza I P.
1862	Jan. 12-31	Siberia, Mouth of R. Selenga, Irkutsk, Selenginsk, Verkneudinsk, Chita, Petrovsk, Nikolaievsk, Upper and Lower Angora Districts II M. & O. & P.
1862	Jan. 13	Hungary, Shemnitz, Nepomuk I P.
1862	Jan. to Feb.	China (Yunnan), Tali Fu III Ho.
1862	Feb. 5	Siberia, Selenginsk I P. A continuation of Jan. 12-31.
1862	Feb. 5	Argentina, Mendoza, several people killed II P.
1862	Feb. 22	New Zealand I P.
1862	March	Siberia, Lake Baikal I P.
1862	Mar. 4	9h. 30m., G.M.T. Philippines, Manila and neighbouring provinces I S.M.
1862	Mar. 18	Germany (Rhine), Liedberg, Gladbach I P.
1862	April 28	Siberia, Selenginsk I M. & O.
		Strong earthquakes at Siberia, Selenginsk in 1803, 1811, 1815, 1818, 1829 and 1839 P.
1862	May 4	Switzerland, Valais, Visp, and Valley of the Rhone, Viège, Stalden, Zermatt I P.
1862	May 20	Chile, Tacna to Arica II P. & Mon.
1862	May 24	Java, Provinces of (Krawang. Preanger), Poerwakarta I P.
1862	May 24	Asia Minor, Marmarizza I P.
1862	May 26	Austria, Tyrol, Kalkstein I P.
1862	May 27	Switzerland, Valais, St. Nicholas I P.
1862	May 27	Austria, Carinthia, Heiligenblut, Döllach I P.
1862	May 28	Peru, Callao, Lima I P.
1862	June 6	Formosa, Tainan, Kagi, Shoka III H.
1862	June 8	Algeria, Relizane I P.
1862	June 20	Chile, Tacna and Arica I Mon.
1862	July 1	Philippines, Island of Guam, Ladrones Islands I S.M.
1862	July 10	Gold Coast, Accra, Jamestown and again on the 28th III P. & O.D.
1862	July 11	Peru, Casma I P.

A.D.		
1862	July 13	Philippines, E. Luzon, along coasts of Baler and Casiguran I S.M.
1862	July 14	Gold Coast II O.D.
1862	Aug. 22	Spain (Seville), Villa Nueva II P.
1862	Sept. 9	8th, 19h., G.M.T. Philippines, N. Luzon (Ilocos Norte, Abra and Cagayan) provinces, Laoag, Aparri II P. & S.M.
1862	Oct. 15	Moluccas, Banda I P.
1862	Oct. 16	Asia Minor, Afiun-Karahissar II P.
1862	Oct. 20	Caucasia, Shemaka I P.
1862	Oct. 30	4h. 30m., G.M.T. Philippines (Laguna), South of Lake Bay I S.M.
1862	Nov. 3	Asia Minor, Smyrna, Chekoud-Cassaba in (Isbarta), Afiun-Karahissar III P.
1862	Nov. 22	Austria, Krema I P.
1862	Nov. 26	Algeria, Takitount I P.
1862	Nov. 29	Asia Minor, Smyrna, Chio, Metelin I P.
1862	Nov. 29	Caucasia, Shemaka I M. & O.
1862	Dec. 19	West Indies, Guadeloupe, Pointe-à-Pitre, Sainte Marie I P.
1862	Dec. 19	Caucasia, Shemaka, Lenkoran, Shusa, Zournabad I P.
1862	Dec. 19	Central America, Guatemala, Nicaragua, *Antigua*, Amatitlan, Escuintla, Port of San José ; also felt in Honduras and throughout Salvador III P. & Mon.
1862	Dec. 21	Persia, Shiraz II P.
1862	Dec. 27	U.S.A., California, San Francisco I P.
1863	Jan. 6	Mauritius, Port Louis I P.
1863	Jan. 17	Hungary, Voros, *Pencz*, Foth, Buda I P.
1863	Jan. 19	Italy, Montecassino, S. Germano (Caserta) I B.
1863	Jan. 22	Austria, Croatia, Karlstadt, Cilla I F.
1863	Jan. 30	Italy, Casamicciola I C.V.
1863	Feb. 22-23	New Zealand, Hawkes Bay, Province of (Napier) I P., O.D., & T.
1863	Feb. 3-27	Switzerland, Valais, Graechen I P.
1863	Mar. 16	Java, Serang I P.
1863	Mar. 22	Italy, Ischia, Casamicciola I C.V.
1863	April 5	Philippines, Iloilo, Antique I P.
1863	April 17	Spain, Granada, Alhendin, Gojar and Ojijares I P.
1863	April 22	Asia Minor, *Rhodes Island*, 13 villages destroyed ; Smyrna and *Island of Cos* III P. & Ti.
1863	April 27	Italy, Ischia, Casamicciola I C.V.
1863	June 3	11h. 20m., G.M.T. Philippines, S. Luzon, Manila, and neighbouring provinces III S.M. & Ti.
1863	June 9	Philippines, S. Luzon, Manila I S.M.
1863	June 9	France (Lower Alps), Digne, Beynes I P.
1863	June 20-27	Spain, Almeria, Albox, Arboleas, Vera, Huercal-Overa I P.
1863	June 29	Peru, Arequipa I Mon.
1863	July 9	Spain (Almeria), Seron I P. Same series as June 20.
1863	July 10	West Indies, Trinidad II O.D.
1863	July 31	Java, Banjoemas I P.
1863	Aug. 8	Spain (Granada), Albunol, Albondon, Manola, Castel de Ferro I P.
1863	Aug. 13	Java (Preanger), Manondjaja, Tjie-Kandjang and Banjoemas, Soeka-Radja I P.
1863	Aug. 16	Asia Minor, Rhodes Island, Archangelo I P.
1863	Sept. 2	Turkey, Dardanelles, Jenidji and Saritchaban I P.
1863	Sept. 7	Algeria, Aumâle I P.
1863	Sept. 27	Philippines, Luzon (Leyte) I P.
1863	Oct. 6	England, Cheshire, Dudley I M. & W.
1863	Oct. 20	Hungary, Mur Valley I P.
1863	Oct. 27	Philippines, Luzon, Tacalaban II P.
1863	Nov. 6	Turkey, Constantinople, Gallipoli, Guemlek, Oumourbey, Brussa II P.
1863	Nov. 24	Asia Minor, Anatolia, Boli I P.
1863	Dec. 7	Ladrones, Guam I S.M.
1863	Dec. 11	Moluccas, Banda I P.
1864	Jan. 2-11	Asia Minor, Rhodes Island, Makri I P.
1864	Jan. 3	Persia and Caucasia, Ardebil, also felt at Lenkoran, Karabagh and Shirwan III P., M. & O.
1864	Jan. 3	Philippines (Cotabato, Zamboanga), *Illana Bay* I S.M.

A.D.		
1864	Jan. 6	Persia, near Ardebil, four villages destroyed III P.
1864	Jan. 6	Austria (Carniola), Sagori I P.
1864	Jan. 10-11	Asia Minor, Makri II P.
1864	Jan. 12	Spain, Murcia, *Lebrilla* to *Carthagena*, Alhama II P.
1864	Jan. 12	2h. 9m., G.M.T. Chile, *Copiapo*, *Tierra-Amarilla*, Ojancos, Nantoco, Chanarcillo, Totoralillo, Pavillon, etc. III P. & Mon.
1864	Jan.	China, Hankow III P., M. & O.
1864	Feb. 16	West Sumatra, Padang, Batu Island (Mandheling and Angkola), Penjaboengan with sea waves III P.
1864	Feb. 16	Iceland, Reykjavik I Th.
1864	Feb. 28	Canada, B.C., Thornes-creek II Ti.
1864	Feb.-Mar.	Italy, Vergato, Tole, Savignano, etc., in the Apennines of (Bologna) I B.
1864	Mar. 22	U.S.A., San Francisco, Santa Clara I P.
1864	May 5	China (Kiangsu), Shanghai, Nanhui, Sungchiang Fu, Chiating, Taitsang I Ho.
1864	May 19	West Indies, Haiti, Jacmel II P.
1864	May 20	Sumatra, Benkoelen I P.
1864	May 21	New Guinea, Dorei, Mt. Arfaks II P.
1864	June 6	Sumatra, Siboga I P.
1864	June 14	Turkey, Salonica to Gallipoli I P.
1864	July 7 *ca.*	Asia Minor, *Enos* Island, *Mais* Island near Rhodes I P.
1864	July 20	Java, Toeban at Rengel I P.
1864	Aug. 14	Turkey (Moldavia), Kalarach II P.
1864	Sept. 26	Canada, B.C., Vancouver, Victoria I P.
1864	Oct. 3	Mexico, Vera Cruz. Puebla, Tlaxcala, ***Soledad***, ***Téehuacan***, *Orizaba* and Cordoba III P.
1864	Oct. 28	Greece, Lamia, Rolan I P.
1864	Oct. 29	British Columbia, Victoria and New Westminster I P.
1864	Dec. 2 to 26	Asia Minor, Bagdad, ***Zarbotia***, Bassorah, Bedra-Djessan, Mendeli II P.
1864	Dec. 7	Sumatra, Padang, ***Taloe*** I P.
1864	Dec. 5	France, St. Amand-de-Boixe, Montignac I P.
1864	Dec. 12	Italy (Tuscany), Mugello I B.
1864	Dec. 26	Sumatra, Tagal, Boemie-Ajoe I P.
1864	Dec. 28 or 31	Italy (Apulia), S. Nicandro-Garganico in Foggia I B.
1865	Jan. 27	England, Gloucester I M. & W.
1865	Mar. 22	Turkestan, Merke I M. & O.
1865	April 11	West Indies, Kingston, Jamaica I Ti.
1865	May 8	11h. 23m. a.m. W. Sumatra, Padang and Benkoelen I O.N.T.
1865	May 16	Austria, Paasdorf, 27 miles N.N.E. of Vienna I F. & Ti.
1865	May 17	2h. 49m. p.m. Java, Ruins of Tjandie-Sewoe and Prambanan in Soerakarta II O.N.T.
1865	May 18	11h. 14m. p.m. Java, *Joenoeng-Tiga* in Tegal, Kedieri, Tjilatjap in Banjoemas, Kadoe, Madoera and other districts II O.N.T.
1865	May 22	Siberia, Selenginsk, Irkutsk, Verkneudinsk I M. & O.
1865	May 26	Formosa, Manca I F.
1865	May 27	Siberia, Shubrisk, Porezkoje II F. & Ti.
1865	July 13	Austria, Styria, Furstenfeld, Pöllau I Ti.
1865	July 16	Java, Ambarawa, 6 and 7 p.m., Banjoe-Biroe and elsewhere in Semarang II O.N.T.
1865	July 19	Italy, Sicily, *Fondo di Macchia*, Baglio, Rondinella, etc., near Etna II B.
1865	Sept. 21	Italy, Citta di Castello (Perugia) II B.
1865	Sept. 25	China (Shantung), around the Taishan III F., M. & O. & Ti.
1865	Oct. 1	Mexico, Amecameca I O.B.
1865	Oct. 8	U.S.A., San Francisco, *Santa Cruz*, Sacramento, Stockton, San José II F.R.
1865	Oct. 18, 19, night	Sumatra (Bangka), Bellinjoe I O.N.T.
1865	Nov. 11-14	Asia Minor, Chios III F., Ti.
1865	Nov. 23	22nd, 20h., G.M.T. Philippines, Manila and adjacent provinces I S.M.
1865	Nov. 25	1h. 40m. and 2h. 40m. p.m. Celebes, ***Tondano*** and ***Kema*** and throughout (Minahassa) III O.N.T.

A.D.		
1865	Dec. 15	Venezuela, Caracas, La Guayra, P. Cabello, Valencia II F.
1865	Dec. 19	India, Chittagong and Bengal I Ol.
1866	Jan. 2	Mexico, *Acatzingo*, *San-Andres-Chalchicomula* in Vera Cruz, Puebla, Oaxaca, Cordova, Orizaba, Tehuacan, *Maltrata* III F. & Ti. O.B. gives I
1866	Jan. 19-21	Asia Minor, Chios I F. & Ti.
1866	Jan. 29	Germany, Pomerania, Rekow near Butow I F.
1866	Feb. 1 & 21	Italy, La Vene (Spoleto) I B.
1866	Feb. 2	Asia Minor, Chios I F.
1866	Feb. 6	Greece, Patras I F.
1866	Mar. 2	Turkey, Epirus, Albania, *Avlona* and *Pollina* III F.
1866	Mar. 8	Siberia, Verkneudinsk and Irkutsk I M. & O.
1866	Mar. 9	0h. 40m., G.M.T. Norway, Prefectur of Trondhjem I O.D.
1866	Mar. 12	Japan (Harima, Tanba) II Mi.
1866	Spring	Formosa, Tamsui I H.
1866	Mar. 20	Asia Minor, Chios I F.
1866	April 22	11h. 9m. a.m., *ca.* Java, Willem and Banjoe-Biroe in Semarang I O.N.T.
1866	May 23	India (Nepal), Katmandu; (Bengal), *Monghyr*, Jubbulpore II Ol.
1866	May 25	China (Chehkiang), Chenhai, Ningpo in Ningpo Fu I Ho.
1866	June 24	Ladrones, Guam I S.M.
1866	June 29	Lat. 31°N. 40°W. I Ti.
1866	July 23	Chile, Copiapo I Mon.
1866	July	Asia Minor, between the Euphrates and the Tigris III F.
1866	Aug. 11	Italy, Monte Baldo (Verona) I B.
1866	Aug. 25 or Sept. 6	Siberia, Petropavlovsk and Lyersny II M. & O.
1866	Sept. 5	U.S.A., Alaska, Kodiac II Ti.
1866	Sept. 26	5h. 37m. p.m. West Indies, Trinidad I O.D.
1866	Sept. 30	Java (Banjoemas) I O.N.T.
1866	Oct. 23	China (Shantung), Chucheng, Chingchou Fu; (Kiangsu), Chiating in Taitsang, Shanghai, Sungchiang in Sungchiang Fu I Ho.
1866	Nov. 4	Russia (Bessarabia), *Soroki* I F.
1866		U.S.A., Kansas, Wamego I F.R.
1866	Dec. 1	2 p.m., *ca.* W. Sumatra, *Taloe*, Padang I O.N.T.
1866	Dec. 29	28th, 19h., G.M.T. Philippines, N. Luzon (Ilocos Norte), Laoag II S.M.
1867	Jan. 2	Algiers, Algiers, *Blidah*, *Chiffa*, *El Affraun*, *El Aim*, *Benrasmi*, *Monzaiaville* III F. & Ti.
1867	Jan. 5	1h. 45m., G.M.T. Philippines (Albay) I S.M.
1867	Jan. 12	China (Kiangsu), Chiating in Taitsang, Shanghai, Sungchiang in Sungchiang Fu I Ho.
1867	Jan. 31	France, Chablis, Planta I F.
1867	Feb. 4	Greece, Cephalonia, *Lixuri*, Argostoli, Cosmopoli III F. & Ti.
1867	Mar. 7-16	Asia Minor, *Mitylene*, 3,000 houses destroyed, Lesbos III F.
1867	Mar. 14	China, Hankow I Ti.
1867	Mar. 15	Switzerland, Lake Maggiore, *Feniolo* I F.
1867	Mar. 21	Salvador, Guiamoco II Mon.
1867	Mar. 26	5h., G.M.T. Philippines (Ilocos Norte) I S.M.
1867	April 2	Salvador, San Salvador II Mon.
1867	April 15	Germany, Essen I F.
1867	April 29	U.S.A. (Missouri), Kansas I Ti.
1867	May 5	China, Pekin I M. & O.
1867	May 7 & 8	Siberia, Selenginsk I M. & O.
1867	May 14	Switzerland (Vaud), Yvonand I F.
1867	May 31	Azores, Sereta, Raminho I F.
1867	June 9	9h. 9m. p.m. Java, *Djokjakarta*, *Bojolali*, and *Klatten*, and all over Java except the Preanger III O.N.T.
1867	June 30	Austria, Littai near Laibach I F.
1867	July 3	India (Madras), Villapuram I Ti.
1867	July 23	Caucasia, Telaf 41°55N. 45°20E., Shemaka, Mukhran, Zurnabad 40°30N. 46°14E., and Elizabetopol 40°40N. 46°20E. I M. & O.

A.D.		
1867	June 30-July 7	Salvador, San Salvador I Mon. & Ti.
1867	Aug. 15-16	Italy, Casamicciola, Island of Ischia I B.
1867	Sept. 9	Greece, Patras, Candia I Ti.
1867	Sept. 20	Malta I Ti.
1867	Near end of Sept.	Greece, Magelang, Solo, Messenia and Lakonia, Gytheion II F.
1867	Nov. 3	1h. 50m. a.m. Moluccas, *Ternate*, Tidore and Hahnaheira I O.N.T.
1867	Nov. 18	2h. 30m. p.m., local. West Indies, Virgin Islands, St. Thomas, St. Johns, St. Croix; sea waves II F., Ti., & O.D.
1867	Nov. 25	Italy, Resina, Torre del Greco in (Naples) I B.
1867	Dec. 18	Formosa, Kelung, Tamsui III Ti.
1867	Dec. 27	1h. 11m., G.M.T. Philippines, Samar Island I S.M.
1867	Dec. 31	Iceland, Skalfandi, Husavik and Akureyri, a few houses destroyed II Th.
1868	Jan. 16-20	China (Chehkiang), Chenhai in Ningpo Fu I Ho.
1868	Jan. 17	Italy, Monte Amiata in (Siena) I B.
1868	Feb. 4	Russian Turkestan, Tashkent II M. & O.
1868	Feb. 18	Caucasia, Akhalkalaki, Kwirily, Toporwan and Ardahan in Kars Province I M. & O.
1868	Feb. 25	Armenia and Caucasia, Erzerum, Alexanderopol, Akhalkalaki II M. & O.
1868	Mar. 17	West Indies, St. Thomas I Ti.
1868	Mar. 18	Caucasia, Telaf, Delishan, Shusha, Jebrail, Sakataly, Shemaka, Belasuvar, Chatakh I M. & O.
1868	Mar. 21	Russia, Grosnyi and Galachewsk Station I M. & O.
1868	Mar. 27	Sandwich Islands, Mauna Loa III F.
1868	April 1	Philippines, Leyte Island I S.M.
1868	April 4	Sandwich Islands II F. See Mar. 27.
1868	April 4	Russian Turkestan, Tashkent II M. & O.
1868	April 4	Sandwich Islands, Hilo with sea waves II F.
1868	April 7	Mexico, San José de Iturbide in San Luis Potosi I O.B.
1868	April 11	Armenia, Kars and Nizhni-Pasin, Erzerum, Tiflis II M. & O.
1868	May 22	Mexico, *Iturbide*, Jalisco, Oaxaca, Puebla, Mexico, Tehuantepec II O.B.
1868	May 25	Mexico, Acapulco I O.B.
1868	June 7	Peru, Socalor or Socota ? I F.
1868	June 21	Austria, Hungary, Jasz Bériny, Pesch I Ra.
1868	June 27	0h. 11m., G.M.T. Philippines, Panay Island, Iloilo I S.M.
1868	June 29	Germany, Essen I F.
1868	June 30	Russia, Tsogonoi village 42°53N. 45°33E., Terek province II M. & O.
1868	July 7	5h. 1m., a.m., local. West Indies, Trinidad I ? O.D.
1868	Aug. 10	France, near Paris, *Meudon*, *Bellevue* I F.
1868	Aug. 13	S. Peru, Bolivia, and N. Chile, E. to Paz, N. to Lima, with sea waves from Truxillo to Concepcion, *Arequipa*, *Tacna*, *Arica*, *Iquique*, *Moquegua*, *Locumba*, also at Copiapo, Pisagua, Chincha III F. & Ti.
1868	Aug. 16	Ecuador, Colombia, Guayaquil, province of (Pinchincha), Imbabura, *Ibarra*, *San Pablo*, *Atuntaqui*, Quito III F. In Ecuador 40,000 and in Colombia 30,000 lives were lost.
1868	Aug. 17	New Zealand, Taranaki II F.
1868	Aug. 19	Bolivia, Cosapillo ? II F.
1868	August	India, Peshawar I Ol.
1868	Aug. 20	Hungary, Jasz Béreny I F.
1868	Sept. 17	6h. 31m., p.m. Java, Tjanisin in (Cheribon), Bandeong and Garoet in the (Preanger) II O.N.T.
1868	Oct. 12	Chile, Copiapo I Mon.
1868	Oct. 18	New Zealand, Hokitika, Nelson, Waitaho, Taranaki I, Ti.
1868	Oct. 19	Mexico, Guerrero, Oaxaca, St. Catharina, Albarradas II F.
1868	Oct. 21	U.S.A., California, *San Francisco*, Oakland, San Leandro, San José, *Redwood City*, S. Clara, S. Cruz, S. Matteo, and north of San Francisco, San Rafael, Petaluna, S. Rosa, Sacramento III F. & F.R.

A.D.		
1868	Oct. 26	New Zealand, Taranaki II Ti. See Oct. 18.
1868	Oct. 29-30	China (Kiangsu), Chenchiang Fu ; (Anhui), Chuhchou Fu, Hochiu in Yingchou Fu I Ho.
1868	Nov. 1-2	Iceland, Faxafloi, Reykjavik, Borgarfjordr ; some houses damaged I Th.
1868	Nov. 1-6	Mexico, *S. Luis Potosi*, *Iturbide* II F.
1868	Nov. 5	Chile, Copiapo II Ti.
1868	Dec. 20	Mexico, Colima, *Manzanillo* III F. Ti. gives II
1869	Jan. 10	India, Assam, *Silchar*, Cachar III F. & Ti.
1869	Feb. 7	Italy, Siena I B.
1869	Beginning of Feb.	Hungary, Csik-szek I F.
1869	Mar. 6 & 11	Colombia and Northern Venezuela, *Bogota*, *Magdalenenstromes* and *Branco* III R.S.
1869	Mar. 15	England, East Lancashire and borders of West Yorkshire I R.
1869	Mar. 29	Argentina, Mendoza I Mon.
1869	Mar. 31	Italy, San Giovanni, Rotondo (Foggia) I B.
1869	Early in the year	Austria (Dalmatia), *Ragusa* I F.
1869	April 18	Asia Minor, Rhodes Island, Symi, Kalymnos II F.
1869	April 20	Chile, Talca I Mon.
1869	April	India, Peshawar I Ol.
1869	June 11	New Zealand, Christchurch and Lyttelton I Ti.
1869	June 25	Italy, Vergato, Zocca, Casio in (Bologna) I B.
1869	June 29	Peru, Arequipa I Mon.
1869	July 7	India (Nepal), Katmandu III Ol.
1869	Aug. 15	Peru and Chile, Lima, Callao, Iquique I F.
1869	Aug. 16	7h., G.M.T. Philippines, Masbate Island III S.M.
1869	Aug. 17	Russia, Saratow, Sokalowberg II F. Eqke. ?
1869	Aug. 19	Peru, Chile, Arica and Ica ; sea waves I Mon.
1869	Aug. 20-24	Peru, Chile, Tacna, *Arica*, *Iquique*, *Pica ;* sea waves I F., Mon. & H.J.
1869	Sept. 2	Caucasia, Shemaka, most violent in Sundi, 12 miles from Shemaka III M. & O.
1869	Sept. 17	West Indies, St. Thomas II F. & Ti.
1869	Sept. 26	Italy, San Geminiano in (Siena) II B.
1869	Oct. 1	3h. 35m., G.M.T. Philippines, S. Luzon, *Manila* (Rizal, Laguna, Bulacan, Cavite, Batangas) and Northern Mindoro II S.M.
1869	Oct. 11	Russia, Crimea, Feodossia, Sudak, Jalta I F.
1869	Oct. 13	Austria, Carniola, Radmansdorf I F.
1869	Oct. 22	U.S.A., all over New England States, *Fredericton* in New Brunswick III F.R. Ti. gives I
1869	Oct. 23	8h. 30m., G.M.T. Philippines, S. Luzon (Lagua) II S.M.
1869	Oct. 26	Chile, Cobija I Mon.
1869	Oct. 31	Germany, Russelsheim, Mannheim, Heidelberg, Wiesbaden I F.
1869	Nov. 1	Siberia, Valley of the Bargusin River, Lake Baikal I M. & O.
1869	Nov. 2	Germany, Mannheim, Grossgerau, Darmstadt I F. & Ti.
1869	Nov. 3	Peru, Arequipa I H.J.
1869	Nov. 16	Algeria, *Biskra*, *Seriana*, Sidi Alba III F.
1869	Nov. 28	Italy, Monteleone, Nicastro and neighbourhood in (Calabria) I B.
1869	Dec. 1	Asia Minor, *Onlah*, *Marmaritsa*, *Mulla*, Smyrna, Rhodes III F.
1869	Dec. 10	Russian Turkestan, Kojent I M. & O.
1869	Dec. 20	India, Rawalpindi I Ol.
1869	Dec. 26	Caucasia, Tiflis, Alexandropol, especially villages Malye, Jamzhili and Jaushtan III M. & O.
1869	Dec. 27	U.S.A., California and Nevada City, Sacramento, *Virginia City*, Stockton, Truckee, Marysville II F. & F.R.
1869	Dec. 28	Greece, Corfu, *St. Maura Island* III F. & Ti.
1870	Jan. 5	Hungary, Pressburg, Tyrnau I F.
1870	Feb. 8	Italy, *Gallignano*, Osimo, Capodimonte. etc., in (Ancona) I B.
1870	Feb. 22	Asia Minor, *Makri*, Rhodes II F.

A.D.		
1870	Mar. 1	Austria, Croatia, Istria, *Lissacz* near Karlstadt, Volosca, Trieste, *Clana* near Fiume II F.
1870	Mar. 2	1st, 19h., G.M.T. Philippines (N.E. Samar) II S.M.
1870	Mar. 25	Argentina, Mendoza I Mon. F. gives 20th.
1870	April 11	China, Bathang II Pa., F. & Ti.
1870	April 22	India, Dacca I Ti.
1870	April 23	Chile, Calama I Mon.
1870	May 11, 12, & 16	Mexico, Vera Cruz, Puebla, Mexico, *Oaxaca*, *Ejutla* and south to Tabasco III O.B., F., & Ti.
1870	May 13	Ladrones, Guam I S.M.
1870	May 23	15h. 55m., G.M.T. Philippines, N. Luzon (Ilocos Norte, Laoag, Cagayan, Isabela and northern mountain provinces) II S.M.
1870	June 1-11	Guatemala, Guatemala, towns and villages destroyed III Mon.
1870	June 4	Colombia, Bogota at 9.50 p.m., local I O.D.
1870	June 24	Syria and Egypt, Damascus, Cairo, Zebedani, Cyprus, Crete, East Coast Red Sea I F.
1870	July 1	Greece, Santorin Island III Ti.
1870	July 7 & 8	Russia, Eastern shore of Black Sea I M. & O.
1870	July 11	Bolivia II F.
1870	July 12	Asia Minor, Smyrna, Crete, Cyprus, Tiflis I F. Ti. gives Tiflis only.
1870	July 12	Salvador and Honduras, *Santa Rosa* II Mon.
1870	Aug. 1	Greece, Athens, Corinth, Patras, *Harbour Itea*, *Chrysos*, Pyraeus, Kalchis III F. & Ti.
1870	Oct. 5	Italy, *Mangone*, Cellara, S. Stefano, other towns in (Cosenza) and the chief town itself III B.
1870	Oct. 20	Canada, Quebec, Baie St. Paul, Toronto, also New York (Maine) I Ti. & O.D.
1870	Oct. 25	Greece, Athens I Ti.
1870	Oct. 28	India, Sind I O.D.
1870	Oct. 30	Italy, *Meldola*, Teodorano, Castrocaro and other places in (Forli) II B.
1870	Nov. 4	3rd, 20h., G.M.T. Philippines, Central Mindanao, epicentre between the *Gulf of Davio* and *Misamis* II S.M.
1870	Dec. 21	Peru, Arequipa I Ti.
1871	Jan.	S. Pacific, Sunday Island I F.
1871	Jan.	Mexico (Tepic), Ahuacatlan, Lextlan, Taba III F.
1871	Feb. 9	Germany, Darmstadt I Ti. F. gives 10th.
1871	Feb. 14, 16 ?	Germany, Darmstadt, Lorsch I F.
1871	Feb. 19	Sandwich Islands I Ti.
1871	Feb. 21	20th, 20h., G.M.T. Philippines, Camiguin Island, Mambajao, Catarman III S.M.
1871	Feb. 22	Peru, Puno I H.J.
1871	Feb. 23	Bolivia, Province of (Cochabamba), *San Antonio* II Mon.
1871	Mar. 4	Siberia, Irkutsk Govt. and (Transbaikal) Prov. and North Mongolia I M. & O.
1871	Mar. 19	Sandwich Islands, Honolulu II Ti. See Feb. 19.
1871	Mar. 25	14h. 46m., G.M.T. Chile, Santiago and Valparaiso, Talca I Mon. & Ti.
1871	Mar. 27	3h. 44m., a.m. Java, *Bandjarnegara* and elsewhere in Banjoemas, Kadoe II O.N.T.
1871	April 11	China, Bathang, 2,300 lives lost III F.
1871	May 25	Malacca, Bintang Island III Ti. Not given by O.N.T.
1871	June 28	27th, 21h. 30m., G.M.T. Philippines, S. Mindanao, Davao I S.M.
1871	July 11	13h. 19m., G.M.T. Philippines, Luzon, N. of 16° of N. Lat. II S.M.
1871	July 20	Italy, Montescudaio, *Guardistallo* and Bibbona in (Pisa) II B.
1871	Aug. 2	Peru, Arequipa I H.J.
1871	Aug. 18	12h. 51m., p.m. West Sumatra (Palembang), *Benkoelen*, and all the west coast of Sumatra, Batavia in Java, Lingga, and Ternate II O.N.T.
1871	Aug. 21	West Indies, St. Thomas III Ti.
1871	Aug. 21	Peru, Callao ; sea waves I F.
1871	Sept.	West Indies, Tortola Island III F.

A.D.		
1871	Oct. 4	12h. 30m. G.M.T. Philippines, S.E. Mindanao, Davao, District, Caraga II S.M.
1871	Oct. 5	9h. 46m., G.M.T. Chile, Iquique, *Tarapaca*, Pica and Matilla I J.H. & Mon.
1871	Oct. 13	Mexico, Manzanillo in Colima I O.B.
1871	Oct. 23	3h. 16m., G.M.T. Argentina, Oran, Jujuy III F. & Mon.
1871	Oct. 22	Italy, Chianti (Siena) I B.
1871	Nov. 5	1h., G.M.T. Philippines, N.E. Mindanao (Surigao), Bislag, Caraga II S.M.
1871	Nov. 29	8h. 30m., G.M.T. Philippines, Basilan, Jolo Islands II S.M.
1871	Dec.	Spain, Cordova, also Oran III Ti.
1871	Dec. 8 & 9	8th, 9h. 30m. and 23h. 30m., G.M.T. Philippines, W. Mindanao, Cotobato, Lanao and Davao districts, *Cotobato*, *Pollok* III S. M.
1871	Dec. 11	Caucasia, Gulija, 39°57N. 43°30E., 56 miles west of Erivan and in the Echmiadzin district II M. & O.
1871	Dec. 19	14h. 30m., G.M.T. Philippines, E. Mindanao (Surigao to Davao) II S.M.
1872	Jan. 9	Canada, Quebec I Ti.
1872	Jan. 11	0h. 1m., G.M.T. Peru, Arequipa I H.J.
1872	Jan. 17	Caucasia, Shemaka II F.
1872	Jan. 26	11h. 30m., G.M.T. Philippines, W. Luzon, north part of (Zambales), Agno, Bolinas II S.M.
1872	Jan. 27-30	27th, 8h. 30m., G.M.T. Philippines (Ilocos Norte) I S.M.
1872	Jan. 28-Feb. 10	Caucasia, Shemaka and neighbourhood III M. & O. & Ti.
1872	Mar. 6	Germany, Dresden, Schonebeck I F.
1872	Mar. 13	Japan (Iwami, Inaba, Hoki) II Mi.
1872	Mar. 26	U.S.A., South California, (Inyo County), Lone Pine III F., F.R., & Ti.
1872	Mar. 27	Mexico, *Oaxaca*, Puebla, Tlaxcala, Vera Cruz III O.B.
1872	April 3	Asia Minor, *Antioch*, 1,800 lives lost, *Aleppo*, Beirut, Damascus III F. & Ti.
1872	April 14	Gold Coast, Accra II Ti.
1872	April 18	Iceland, around Skjalfandi, many houses in Husavik and farms damaged II Th.
1872	May 14	Italy, Cividale (Udine) I B.
1872	June	Persia, Hamadan III F.
1872	July 13	9h. 31m., a.m. Java, *Koeningan* in Cheribon and Tjawie in the Preanger I O.N.T.
1872	July 15	Armenia, Shemaka II Ti.
1872	July 22	14h. 50m., G.M.T. Philippines (Camarines and Albay) I S.M.
1872	July 24	China (Kiangsu), *Chiangning Fu*, Chenchiang Fu, Yangchou Fu; (Anhui), Luchou Fu II Ho.
1872	Aug. 24	13h., G.M.T. Philippines, Davao I S.M.
1872	Sept. 6	5th, 16h., G.M.T. Philippines, N. Samar, Catanduanes Island, (Sorsogon and Albay) I S.M.
1872	Sept. 10	12h. 20m., G.M.T. Philippines, Luzon (N. Mountain) I S.M.
1872	Sept. 21	China (Kiangsu), *Chenchiang Fu*, Paoshan, Chungming in Taitsang, Sungchiang, Chingpu in Sungchiang Fu, Chiahsing Fu; (Chehkiang), Ningpo Fu III Ho.
1872	Oct. 10	Java, Salatiga in (Semarang) I O.N.T.
1872	Oct. 30	15h. 53m., p.m. Java, Soekaboemi in the (Preanger) I O.N.T.
1872	Dec. 10	U.S.A. (Montana), Helena and Deer Lodge I F.R.
1872	Dec. 12	Italy, Montecassino (Caserta) I B.
1872	Dec. 15	India, Balchistan, *Lehri*, Sebri, Shikarpur in (Sind) III F. & Ti.
1872	Dec. 29	3h. 48m., G.M.T. Philippines, S. Luzon, Manila, *Rizal*, *Cavite*, *Batangas*, *Bataan*, *Zambales* provinces and Northern Mindoro II S.M.
1872	Dec. 29, 30, & 31	Salvador, San Vicente I Mon. Ti. gives III
1873	Jan. 3	Mexico *Morelia* in Michoacan, Guanajuato, Jalisco I O.B.

A.D.		
1873	Jan. 6	Mexico, Ucareo in Oaxaca II O.B.
1873	Jan. 16	15h. 45m., G.M.T. Philippines (Batangas, N. Mindoro, Tayabas, Cavite, Laguna) I S.M.
1873	Feb. 1-3	Asia Minor, Samos Island II F. & Ti.
1873	Feb. 5	8h. 16m., a.m. Java, *Tjiamis* and Salaija in Cheribon I O.N.T.
1873	Feb. 22-Mar. 19	Salvador, felt as far as Gracias in Honduras, damage 12 to 15 miles round the capital III' Mon.
1873	Mar. 5	Salvador, San Salvador, *St. Vincent* II F. & Ti.
1873	Mar. 12	Italy (Marches), Camerino, S. Ginesio and Fabriano, also Karlstadt in Croatia II B. & F.
1873	Mar. 18	5h., G.M.T., Philippines, Samar Island, S.E. part II S.M.
1873	Mar. 19	Salvador, San Salvador, St. Vincent III F. & O.D.
1873	Mar. 27	China, Hongkong I F.
1873	Mar. 31	30th, 17h. 58m., G.M.T. Philippines, N. Luzon (Ilocos Norte and Ilocos Sur) II S.M.
1873	April 11	Salvador, San Salvador, St. Vincent, 300 victims III Mon.
1873	May. 15	Chile, Valpariaso I F. Mon. gives 14th.
1873	May 16	Italy, Sassuolo (Modena), Reggio and Scandiano I B.
1873	June 10	Peru, Arequipa I F. & H.J.
1873	June 11	15h. 15m., G.M.T. Philippines, N.E. Mindoro, Romblon Island, Marinduque Island I S.M.
1873	June 29	Italy, Belluno, Vittorio, Alpago and many parts of (Belluno and Treviso), and at Venice, Verona III B.
1873	July 5	Argentina, La Plata, Salta, Oran I F.
1873	July 7	Chile, Cuillola, Valparaiso, Santiago, reached southwards to Curico III Mon. & F. Ti. gives II
1873	July 12	Italy, *S. Donato*, Picinisco, Sora and many other places in (Caserta) II B.
1873	July 19	France, Rhone Valley, Donzère, Viviers, Montélimart I F.
1873	Aug. 9	7h. 58m., a.m. Sumatra, *Mandheling*, Natal in Batang and over large part of West Sumatra and in Nias III O.N.T.
1873	Aug. 21-26	Guatemala I Mon.
1873	Sept. 11	Italy, Cosenza I B.
1873	Oct. 7	Germany, Darmstadt I Ti.
1873	Oct. 7	5h. 8m., a.m. Sumatra, *Klein Mandheling* I O.N.T.
1873	Oct. 13	Panama, Aspinwall I Ti.
1873	Oct. 15	Russia, Monastery Kopenkovat, Uman District, Kief Govt. II M. & O.
1873	Oct. 18	6 p.m., *ca.* Java (Malawar) Mountains and Sookaboemi in the (Preanger) and Batavia I O.N.T.
1873	Oct. 22	Germany, Herzogenrath I F.
1873	Oct. 26	Greece, Zante I Ti. & F.
1873	Nov. 14	9h. 30m., G.M.T. Philippines, S. Luzon, *Laguna*, *Tayabas*, and Marinduque Island, Mauban, Lucban, Boac II S.M.
1873	Nov. 22	2h. 12m., G.M.T. Chile, Santiago, Caldera, *La Serena* I Mon.
1873	Nov. 23	Chile, Valparaiso, Santiago, La Serena and Mendoza II Mon.
1873	Dec. 5	Argentina, Jujey I Mon.
1873	Dec. 13-14	Italy, Mignano and S. Pietro in Fine in (Caserta) I B.
1874	Jan. 17	16th, 20h., G.M.T. Philippines (Sorsogon), Masbate Island I S.M.
1874	Feb. 6	Venezuela, La Guayra, Petare, Caracas II Ti.
1874	Feb. 24	Italy, Aquila I B.
1874	Feb. 28	Japan (Tesbio), Yezo II O.
1874	Mar. 16	Mexico, Ayutla, Acapulco, *Chilpancingo* in (Mexico), Guerrero, Puebla, Morelos, Vera Cruz, origin coast of San Marcos I O.B.
1874	Mar. 20	Algeria, Miliana, Cherchel I F. & Ti.
1874	April 14	13th, 22h. 45m., G.M.T. Philippines, N. Luzon, N. of 16°N. I S.M.
1874	May 4	Asia Minor, Diarbekir and Mardin II F.

A.D.		
1874	May 16	Germany, Mainz I F.
1874	June 23	China, Hongkong I Ti.
1874	June 27	Turkey, Constantinople I Ti.
1874	July 8	2h. 32m., G.M.T. Philippines, Central Luzon, *Pangasinam* (Union), *Benguet* (Nueva Vizcaya,) *Casiguran Bay*, (Isabela, Tarlac, Zambales, Pampanga, Nueva Ecija and Bulacan) I S.M.
1874	July 28	Persia, Tabriz I F.
1874	Aug. 24	Russia, Nasran Fortress, 16 miles from Vladikavkas I M. & O.
1874	Aug. 25	24th, 22h. 30m., G.M.T. Philippines, W. Mindanao (Zamboanga and Basilan) II S.M.
1874	Aug. 25	Russia, Vladikavkas, Nasran I F.
1874	Aug. 26	West Indies, Porto Rico I Ti.
1874	Sept. 3	3h. 2m. Guatemala, Antigua, Guatemala, Chimaltenango. Amatitlan, Escuintla, 116 lives lost III F., Mon., & O.D.
1874	Sept. 16	2h. 9m., G.M.T. Philippines, E. Luzon (Tayabas), *Casiguran Bay* (N. Camarines, Laguna, Rizal, Bulacan, Nueva Ecija and Nueva Vizcaya) II S.M.
1874	Sept. 17	Italy, Parma, San Pier d'Arena and other places in the north I B.
1874	Sept. 26	West Indies, Antigua III Ti.
1874	Sept. 26	Italy, Randazzo in Catania I B.
1874	Oct. 7	Italy, Tossignano, Modigliana, Firenzuola and other places in (Romagna) I B.
1874	Oct. 17	Malta I Ti
1874	Oct. 18	Afghanistan, Cabul III F.
1874	Oct. 26	Chile, Valparaiso, Santiago I Ti.
1874	Nov. 7 & 8	France, Nièvre, Corvol-l'Orgueilleux I F.
1874	Nov.	Afghanistan, Cabul II Ti.
1874	Nov. 13	Mexico, *Jalapa* in Vera Cruz, Oaxaca, Tlaxcala, Puebla, Mexico, Guanajuato II O.B.
1874	Nov. 10	Mexico, *Puebla*, Oaxaca, Colima I O.B. See Nov. 13.
1874	Dec. 1	Iceland, Northeastland, Myvatnsveit, some houses damaged I Th.
1874	Dec. 6	Italy, Sora, Arpino, Arce and neighbourhood in (Caserta) I B.
1875	Jan. 1	Chile, Coquimbo, La Serana I Ti.
1875	Jan. 8	Italy, Acireale and neighbourhood in (Catania) I B.
1875	Jan. 14	Germany, Ronsdorf I F.
1875	Feb. 11-27	Mexico, Guadalajara, east to Leon, north to Chalchihuites south to Zacoalco, *San Cristobal*, Guanajuato III F., O.B.
1875	Mar. 9	8th, 19h. 30m., G.M.T. Philippines (Abra and Mountain Provinces) II S.M.
1875	Mar. 11	Mexico, *San Cristobal* and Colima I O.B.
1875	Mar. 18	Italy, Rimini, Cesena, Cervia, throughout Central Italy and a large part of Northern Italy I B.
1875	Mar. 28	New Caledonia, Loyalty Islands, Lifu ; sea waves III F
1875	April 9	Peru, Truxillo II F. Not given by Mon.
1875	April 20	India, Darjeeling I Ti.
1875	April 26	Austria (Silesia), Kattowitz, Königshütte I F.
1875	April 29	Greece, Kiparissa II F.
1875	May 3-5	Asia Minor, *Ischikli*, 1,000 houses destroyed, *Yoril*, *Yaka* III F.
1875	May 12	Asia Minor, Uschak III F.
1875	May 16-18	On the later date at 11 a.m. Colombia and Venezuela, *Seberatina*, *Cucuta*, San Cayetano, Santiago, P. de Arboletes, San Cristobal, S. Antonio, Capacho, Guasimo, Verena, Tarida, Rosario, Salazar, 16,000 lives lost III Ti., O.D.
1875	May 19	3h. 30m., G.M.T. Philippines, S.E. Luzon (Carmaines), *Nueva Caceres*, Iriga, Buhi, etc. II S.M.
1875	June 9	Spain, Barcelona I Ti.
1875	June 18	U.S.A. (Ohio, Indiana, Illinois) I Ti.
1875	July 25	Russia, Crimea, Sebastopol I M. & O. & Ti.
1875	Aug. 7	Caucasia, Shemaka and its district III M. & O.
1875	Aug. 17	Austria (Galicia), Lubin, Lemberg, Dochobyczow I F.

A.D.		
1875	Sept. 3 and following days	15h. 37m. local. India, Assam, Shillong, Gauhati, Tezpore, Shibsagar, Nowgong II O.D.
1875	Sept. 14	New Zealand, Gisborne, Wellington, Blenheim I Ti.
1875	Oct. 24	11h. 32m., p.m. Java, *Menendjaja*, Bandeong, and elsewhere in the Preanger and in Cheribon I O.N.T.
1875	Nov. 23	Germany, Saxony, Reichenbach, Auerbach, Plauen I F.
1875	Dec. 5	Peru, Abancay I H.J. F. gives Jan. 5, 1876, and III
1875	Dec. 6	Italy, S. Giovanni Rotondo and S. Marco in Lamis in (Foggia) and over northern parts of Central Italy II B.
1875	Dec. 8	West Indies, Porto Rico, *Arecibo* II F.R.
1875	Dec. 12	India, Lahore, Peshawar II F. & Ti.
1875	Dec. 13	Java, North Coast, Koeningan, Cheribon. 1,053 habitations destroyed III F.
1875	Dec. 20	West Indies, Porto Rico, Arecibo II F. & Ti. See Dec. 8
1876	Jan. 4-5	Peru, Abancay, Dept. Apurimac III F. Not given by Mon. or H.J.
1876	Feb. 11	Chile, Illapel, Salamanca and Chalinga II Mon.
1876	Feb. 12	Russia, Caspian Sea. Island of Arhamoede? III F.
1876	April 5	Argentina, Buenos Ayres I Ti.
1876	April 28	10h. 43m., p.m. Java, *Bandjarnegara* in (Banjoemas), Bagelen, Kadoe, Tegal in (Pekalongan) I O.N.T.
1876	April 29	Italy. Monte Baldo in (Verona) I B.
1876	May 20	Italy, Spoleto in (Perugia) I B.
1876	May 28	3h. 57m., a.m., Moluccas, Amboina I O.N.T.
1876	May-June	Italy, Corleone (Palermo) I B.
1876	June 18-26	Greece, Corinth, Athens, Euboea, Volo II F. Ti. gives June 20.
1876	July 9	Greece, Corinth II F.
1876	July 17	Austria, Vienna, from Passau to Pressburg, centre near Scheibbs I Ti. & Ra.
1876	July 19	New Zealand, Wanganui, Blenheim, Napier I Ti.
1876	Aug. 4	China (Yunnan), Yungping, Yungchang Fu III Ho.
1876	Aug. 12	Greece, Patras II Ti.
1876	Sept. 13	Italy (Calabria), Reggio I B.
1876	Oct. 17	Germany, Dortmund I F.
1876	Oct. 26	Italy, Palestrina and neighbourhood in (Latium) I B.
1876	Nov. 10	Chile and Argentina, Mendoza, Illapel, Salamanca and Chalinga I Mon.
1876	Dec. 6	Hungary, Mohacs I F.
1877	Feb. 21	10h. 52m., a.m. Java, *Ledok* in Bagelen, Tegal (Preanger, Banjoemas and Pekalongan) I O.N.T.
1877	Mar. 5	Sweden (Nerke), Hallsberg I F.
1877	April 4	Austria, Karlstadt I F.
1877	May 9	Chile, Peru, Arequipa, *Cobija*, *Tocopilla*, *Iquique*, Tarapaca, Arica, origin 71°W. 21°58.; sea waves III F. & Mon.
1877	May 14	Peru, Callao, Lima I F.
1877	May 17	Bolivia, La Paz I Mon.
1877	June 2	3h. 6m., G.M.T. Philippines, Central Luzon, N. & N.E. (Pangasinan) I S.M.
1877	June 24	Germany, between Cologne and Aix La Chapelle, Herzogenrath I F. & Ti.
1877	June 24	23rd, 23h., G.M.T. Philippines (Batangas, Cavite), *Lake Bombon* II S.M.
1877	July 5	4h. 7m., G.M.T. Philippines, S.E. Luzon, and the Vizayas, *Camarines* (Albay and Masbate) II S.M.
1877	July 23	8h. 24m., G.M.T. Philippines, north part of *Leyte Island*, *Carigara* II S.M.
1877	July 26	Chile, Coquimbo, Chinbo and Tamaya II Mon.
1877	Aug. 8	Caucasia, Georgia, Oni and Utseri, 43°33N. 42°40E., on River Rion I M. & O.
1877	Aug. 24	Italy, Veroli (Latium) I B.
1877	Aug. 29	Chile, Caldera, Coquimbo, Vallenar II Mon.
1877	Oct. 8	Switzerland, Geneva I F. & Ti.
1877	Oct. 12	U.S.A. (Oregon), Portland I F.R.
1877	Oct. 13	Turkey, Island of Marmora II F.
1877	Nov. 26	Peru, Chachapoyas II F.
1877	Dec. 23	Italy, Viterbo (Latium) I B.

A.D.		
1877	Dec. 28	Austria, Styria, Neumark, Judenberg I F.
1878	Jan. 10	New Hebrides, Tanna Island : sea waves II F.
1878	Jan. 20	Sandwich Islands, Maau ; sea waves II F.
1878	Jan. 23	Peru and Chile, earth motion extended from Iquique to Arequipa, *La Noria*, *Pica* (Tarapaca, Mantilla), Pisagua, Arica, Callao : sea waves inundated coastal towns III F., Mon. Ti. gives I
1878	Feb. 11	New Hebrides, Tanna, with sea waves I F.
1878	Feb. 12 or 13	Italy, Cascia (Perugia) I B.
1878	Feb. 28	Chile, Tarapaca I F.
1878	Mar. 2	India, Punjab I O.D.
1878	Mar. 3	Hungary, Mako I F.
1878	Mar. 12	Italy (Bologna, Romagna) I B.
1878	Mar. 22	Mexico, *San Cristobal* and Guadalajara I O.B.
1878	Mar. 28	Russian Turkestan, Bakhti Fort in Sergiopol district I M. & O.
1878	Mar. 31	Caucasia, Gorachevodsk convict settlement II M. & O.
1878	April 12	Venezuela (Bolivar), *Gua*, Caracas III F.
1878	April 19	Asia Minor, *Ismid*, *Esme*, *Sapardjia* III F.
1878	May 4	Caucasia, Village Ullu-gatain in S. Daghestan II M. & O.
1878	May 13	Venezuela, Caracas, Gua I Ti. See April 12.
1878	May 22-31	Mexico, Loreto in Lower California II O.B.
1878	June or July	New Hebrides, Tanna II Ti.
1878	June 7	Italy, Cartignano (Cuneo) and neighbourhood I B.
1878	July 16	Caucasia, Fort Kishan-aukh, Terek prov. and neighbourhood I M. & O.
1878	Aug. 13	4h. 14m., G.M.T. Philippines, epicentre S.W. of Luzon, near the west of (Cavite and Zambales), it was felt from Mindoro to (Union and Isabela) I S.M.
1878	Aug. 21	Austria, Croatia, Nassenfuss I F.
1878	Aug. 26	N.W. Germany, Cologne, Rhine provinces from Cleve and Emmerich to Kyllburg and Ottweiler I F.
1878	Aug. 27	Siberia, River Irtish, Omsk I Ti.
1878	Aug. 29	U.S.A., Alaska, Makushin in Unalaska Island II F.R.
1878	Sept. 9	7h. 45m., p.m. Colombia, Popayan II O.D.
1878	Sept. 10	Italy, Fivizzano and neighbourhood in (Massa) I B.
1878	Sept. 15	Italy, Bettona, Giano, Foligno, Spoleto and other towns in (Umbria) II B.
1878	Sept. 17	16th, 16h. 50m., G.M.T. Philippines, S.E. Mindanao, Davao District, near Mt. Apo II S.M.
1878	Oct. 2	Salvador, San Salvador, Usulatan, *Jucuapa* ruined, S. Maria, Tecapa, Chenameca, many villages ruined and lives lost III Mon., F. & Ti.
1878	Oct. 4	Italy, Mineo and neighbourhood in (Catania) I B.
1878	Oct. 4	U.S.A., Hudson River, Marlborough, Peekskill I Ti.
1879	Jan. 8	Russia, Alagir, 43°2N. 44°7E., Perek prov. I M. & O.
1879	Feb. 2	Chile, Argentina, Terretorio, Magallanes and Tierra de Fuego I Mon.
1879	Feb. 23	Italy (Cascia), Norcia and Terravall in (Perugia) I B.
1879	Mar. 13-Apr. 2	Persia, Tabriz to Mianeh, Zendjan, *Maran*, *Tark* III F.
1879	Mar. 28	Midday, Java, Tjianjoer and other places in the (Preanger, Batavia, Bantam, Cheribon and Tegal) II O.N.T.
1879	April 27	Italy, Casio, Modegliana and neighbourhood in (Romagna) I B.
1879	May 2	Russia, Bessarabia, Schaba in Soroki II F.
1879	May 17	Mexico, Vera Cruz to Mexico, *Orizaba*, *Cordoba*, Puebla, Oaxaca I O.B.
1879	June 5	11h. 25m., a.m. Java, *Rangkas Bitoeng* and other places in (Bantam, Batavia and Cheribon) I O.N.T.
1879	June 11	Canada, St. John, Montreal I Ti. Probably small.
1879	June 29-July 1	China (Shensi), *Chishan* in Fenghsiang Fu, Hanchung Fu, Hsian Fu ; (Chihli), Taming Fu III Ho.
1879	July 1	June 30th, 18h. 38m., G.M.T. Philippines, N.E. Mindanao (Surigao) III S.M. There followed other very strong earthquakes on July 5, 24 and Aug. 8.
1879	July-Aug.	Italy, on the eastern side of Etna I B.
1879	Aug. 29	28th, 22h., G.M.T. Philippines, Mindanao, *Cotobato* I S.M.

A.D.		
1879	Sept. 28	Philippines, Mindanao, Davao I S.M.
1879	Oct. 9	Russia, Varenska, Gostagaievska, 45°2N. 37°27E., Troitzkaya 45°8N. 38°6E., and Kurgan 44°56N. 40°.15E., stations in (Trans-Kuban) Prov. I M. & O.
1879	Oct. 10	Hungary and Servia, Drenkova, Vel. Gradiste, Zelenik, Kudrez and Golubac II F. & O.D.
1879	Oct. 14	1h., G.M.T. Philippines (Ilocos Norte), *Baccarra* II S.M.
1879	Oct. 14	Austria, Old and New Moravia, Golubacz near Weisskirchen II F.
1879	Oct. 28	S. Hungary and felt in Transylvania, Servia, Roumania, and Bessarabia III M. & O.
1879	Oct. 31	Hungary, Gross-Szent-Miklós I F.
1879	Nov. 21	Hungary, Temesvar I F.
1879	Dec. 19	Philippines, N. Luzon (Ilocos Norte), Lavagan and other towns II S.M.
1879	Dec. 29	Switzerland, Morges, Montreux, Aubonne, Ouchy I Ti.
1879	Dec. 31	Salvador, San Salvador, *Illopango, San Marcos. Santa Somas*, Sayapango III F. & Mon.
1880	Jan. 7	Switzerland, Grisons I Ti.
1880	Jan. 7	Mexico, Matehuala in San Luis Potosi and *Doctor Arroyo* in Nuevo Leon I O.B.
1880	Jan. 24	Germany, Pfalz, part of Baden, Wurttemberg I F.
1880	Jan. 25	West Indies, Cuba, San Cristoval, Cienfuegos, Havana III Ti.
1880	Feb. 12	Austria, Karlstadt I F.
1880	Feb. 21	Hungary, Severin near Karlstadt I F.
1880	Feb. 22	Japan, Yokohama I Mi.
1880	Mar. 17	Austria, Karlstadt I F.
1880	Mar. 23	Turkestan, Samarkand I F.
1880	Mar. 28	27th, 21h. 4m., G.M.T. Philippines, E. Panay, N.W. Negros I S.M.
1880	Mar. 28	Asia Minor, near Sinope, Haleddi II F. & Ti.
1880	April 16	Mexico, Acapulco, San Marcos, origin coast of San Marcos I Bo.
1880	June 15	Hungary, Nagy-Berezna, Porcsceny and Uzsok I F.
1880	July 4	Throughout Switzerland, Brieg, Zug I F. Same as under.
1880	July 4	Italy, Varzo and *Valvedro* at the foot of the Simplon and as far as Milan, centre in the Valais I B.
1880	July 15	14th, 16h. 53m., G.M.T. Philippines, east range of Luzon (Tayabas, Laguna), east of *Lake Bay* II S.M.
1880	July 18	4h. 40m., G.M.T. Philippines, Central and South Luzon (Tayabas, Cavite, Laguna, Rizal, Bulacan, Bataan, Pampanga. Tarlac, Nueva Ecija, Pangasinan), especially on the banks of River Pasig, the Great and Little Pampanga and the Agno III S.M.
1880	July 20	7h. 40m., G.M.T. Philippines (Bulacan, Bataan, Pampanga, Tarlac), *Manila*, most violent in the towns surrounding Lake Bay, especially south and west of the Lake III S.M.
1880	July 22	Asia Minor, Smyrna II F.
1880	July 29	Asia Minor, Smyrna, district Menemen, Cassaba, Burnabad, felt in Mitylene, Chios and Samos III F. & Ti.
1880	July 24-28	Italy, Ischia and Ventotene I B. & C.V.
1880	Aug. 15	Chile, Aconcagua, *Illapel*, Valparaiso, *Quillota* and to Coquimbo I Mon. & Ti. F. gives 14th and II
1880	Aug. 19	Argentina, Mendoza I Mon.
1880	Sept. 1	4h. 35m., p.m. Java, Sumatra, *Bantam*, Tangerang in (Batavia, Preanger). Lampong I O.N.T.
1880	Sept. 2	Greece, Kalavrita, Strezoba, Dara I F.
1880	Sept. 23	14h. 30m., G.M.T. Philippines, W. Luzon (Zambales) coast I S.M.
1880	Sept. 29	U.S.A , Alaska, Ukmok Island I F.
1880	Oct. 3	Hungary, Klausenburg, Maros I F.
1880		Caucasia, Shemaka I M. & O.
1880	Oct. 26	U.S.A., Alaska along the coast, Sitka II F.

A.D.		
1880	Nov. 9	Hungary, Agram and Laibach, Pettau, Gurkfeld, earthquake felt from Krems in the north, Pest in the east, Serajewo and Pola in the south, Gorz and Klagenfurt in the west I F.
1880	Nov. 14	Austria, Innsbruck, Hall I F.
1880	Dec. 2	Russian Turkestan, Shemaka, Verny extending to Kurumdof 39°35N. 73°40E. and Karakul I M. & O. F. gives II
1880	Dec. 11	Hungary, Agram I F.
1880	Dec. 18	Caucasia, Shemaka II F. & Ti.
1880	Dec. 25	Roumania and Russia, Tekutsh, Waslui near Jassy, Bessarabia, Odessa I F.
1881	Jan. 5	6h. 12m., a.m. Celebes and Timor, *Koepang* I O.N.T.
1881	Jan. 27	Switzerland, Berne I F.
1881	Jan. 28	Russia, Narva, Korff, Logena, Repnik, Iwangorod, or Nowgorod I F.
1881	Jan.-Nov.	Italy, Bologna, Scanello, Quaderna and elsewhere in (Romagna) I B.
1881	Jan. 31	Russia (Transbaikalia), Petrovsk I M. & O.
1881	Feb. 1	Hungary, Carniola, Laibach to Agram I F.
1881	Beginning of Feb.	France, Breauté, Goderville near Rouen I F.
1881	Feb. 12	Italy, Coda de Volpe, Macchia and neighbourhood near (Etna) I B.
1881	Middle of Feb.	Azores, San Miguel III F.
1881	Feb. 25	Hungary, Agram I F.
1881	Feb. 27	Hungary, St. Ivanzelina near Agram, Glavnica I F.
1881	Mar. 4	Italy, Ischia, Casamicciola, Fango, Lacco-Ameno II B.
1881	April 3	Asia Minor, Chios Island, Kastro, centre at *Nevita* and East Coast, 4,181 lives lost III F.
1881	April 9-10	Asia Minor, Chios II F.
1881	April 10	U.S.A.. California, Santa Clara Valley, *Modesto*, centre in San Joaquin Co. I F.R.
1881	April 11	Bohemia, Kladno I F.
1881	April 15-30	Nicaragua, Managua, San Juan del Sur I F. & Mon.
1881	May 20	Asia Minor, Chios II F. Continuation of April 3.
1881	May 30	Asia Minor, Van, Village of Tegut and environs III M. & O. F. gives June 7th.
1881	June 9	Switzerland, Lake Geneva, Martigny, Monthey, Bex, Aigle, Montreux, Lausanne, Morges, Geneva, *Berne* I F.
1881	June 10	Asia Minor, Chios I F.
1881	June 10	Formosa, Unrin I H.
1881	July 11	4h. 35m., G.M.T. Philippines, S. Panay and N.W. Negros Island II S.M.
1881	July 19	Austria, Tyrol, Arzo I F.
1881	July 22	Switzerland, Geneva, St. Julien, Macon, Neuchâtel, Berne, Basel I F.
1881	July 22	France and Italy, southern part of Savoy and adjacent parts of Italy I B.
1881	July 27	8h. 30m., G.M.T. Philippines (Nueva Vizcaya), Bayombong II S.M.
1881	Aug. 26	Asia Minor, Chios, Tschesme III Ti. & F.
1881	Aug. 26	England, Nottinghamshire I M. & W.
1881	Aug. 28	Persia (Azerbaijan), *Choi*, Tabriz II F.
1881	Sept. 1	4h. 20m., G.M.T. Philippines (Nueva Vizcaya), Bayombong III S.M.
1881	Sept. 10	Italy, Orsogna, Lanciano and other places in (Chieti) II B.
1881	Sept. 18	17th, 20h. 55m., & 18th, 14h. 40m., G.M.T., two earthquakes. Philippines (Nueva Vizcaya), Bayombong II S.M.
1881	Sept. 20 to Oct. 15	6h. 25m., G.M.T. Philippines (Nueva Vizcaya), Bayombong II S.M.
1881	Sept. 28	Armenia, Tschangri ? Tschandorli in Asia Minor II F.
1881	Sept. 30	Sandwich Islands, Honolulu, Maui Island I F. & Ti.
1881	Oct. 25	Japan (Nemuro), Kunashiri, Kuril Islands II O.
1881	Nov. 5	Austria (Carinthia), Klagenfurt, Villach, Tamsweg, St. Michael I F.

A.D.		
1881	Nov. 18	Switzerland and Austria, St.Gallen, Ragaz (Appenzell) I F.
1881	Nov. 24	Samoa, Tonga II F.
1881	Nov. 30	Hungary, Agram I F.
1881	Dec. 5	New Zealand, Christchurch I O.D.
1881	Dec. 20	Kamtcheon ? Kamechik in Bulgaria II Ti.
1881	Dec. 29	Asia Minor, Kiangri II Ti.
1881-1882		Italy, Latera, Rocca Respampani and elsewhere in (Viterbo) I B.
1881	Dec. 31	Indian Peninsula and Bengal, *Port Blair*, Andema and Nicobar Islands I O.D.
1882	Jan. 23	China, Prov. of (Kancheon) III F.
1882	Jan. 24	Switzerland (Tyrol), Tannheim, Schattwald I F.
1882	Jan. or Feb.	Ceylon, Trincomali : sea waves II F.
1882	Feb. 27	Switzerland, Tyrol, *Veltlin*, Bondo, Val Bregaglia and Brescia I F.
1882	Feb. 27	Italy, Castione, Rovetta, etc. in (Bergamo) I B.
1882	Mar. 2	8h. 57m., G.M.T. Guatemala, Guatemala, *Antigua*, Salama I F & O.D.
1882	Mar. 3	Costa Rica, San José, Gracia, Cartago II Mon. & F.
1882	Mar. 6	Argentina, Dept. of Paulin, Catamarca II Mon.
1882	Mar. 10	1h. 57m., p.m. Java, *Pekalongan* (Bantam and Banjoemas) I O.N.T.
1882	Mar. 21	Asia Minor, Chios I Ti.
1882	Mar. 26	Italy, Cascia in Perugia and all around I B.
1882	April 10	11h. 30m., G.M.T. Philippines (Cotabato), Mindanao I S.M.
1882	May 3	Azores, Fayal II Ti.
1882	May 17	Asia Minor, Island of Scarpanto I F.
1882	June 6	Italy, Isernia, *Monteroduni*, Longano in (Campobasso) II B.
1882	June 9	6h., *ca.* Guatemala, Guatemala I O.D.
1882	July 17	Austria (Carniola), *Sessana*, Laibach, Loitsch I F.
1882	July 19	Caucasia, Temir-Khan-Shura I M. & O.
1882	July 19	Mexico, *Mexico*, *Puebla*, *Oaxaca*, Vera Cruz, Morelos, Jalisco, Tehuantepec III O.B.
1882	Sept. 7	Central America, *Panama*, *Aspinwall*, Caracas, Nicaragua, Rivas, Greytown, Colombia, Buenaventura and Cartagena, Ecuador, Guayaquil to Maracaibo III F. & F.R.
1882	Oct. 10	8h. 57m., G.M.T. Philippines, S.E. Luzon (Camarines), Nueva Caceres II S.M.
1882	Oct. 13	India (Assam), Silchar II O.D.
1882	Oct. 29	Iceland, North coast of Thistillfjördr I Th.
1882	Dec. 2	China (Chihli), Paoting, Tinghsing in Paoting Fu, Hochien Fu, Tiensin Fu II Ho.
1882	Dec. 6	Philippines, North part of Cebu Island, South Masbate, *Bantayan* II S.M.
1882	Dec. 7	Mexico, San Marcos I Bo.
1882	Dec. 21	Iceland, Akureyri I Th.
1883	Feb. 10	9th, 19h. 28m., G.M.T. Philippines (Nueva Vizcaya), Benguet in (Abra) II S.M.
1883	Mar.	Italy, neighbourhood of Etna, connected with an eruption I B.
1883	Mar. 8	Colombia and Panama, Derien (Antioquia), Santa Rosa, Yarumal I F. & Mon.
1883	April	India, Peshawar II F. & Ti.
1883	May 3	Persia, Tabriz and most of (Azerbaijan) III M. & O. & F.
1883	May 19	Ecuador, Latacunga II F.R.
1883	June	Austria (Bukowina) II Ti.
1883	July 28	Italy, Casamicciola in (Ischia) III B.
1883	July	Salvador, San Salvador I Mon.
1883	Beginning of Aug.	Mexico, Pachuca II F. Not given by Bo.
1883	Aug. 5	Greece, Thermia Island, Kystnos II F.
1883	Aug. 20	Mexico, Patchusa II Ti.
1883	Aug. 27	East Indies, Straits of Sunda with eruption of Krakatoa and sea waves III F.
1883	Sept. 22	Sumatra, Tanahdatar in the Padangsche Bovenland I O.N.T.

A.D.		
1883	Oct. 1	Peru, Arequipa I Mon. & H.J.
1883	Oct. 6	U.S.A., Alaska, eruption of Augustin and sea waves I. F.
1883	Oct. 9	Algeria, Philippeville, Jemmappes, Stora I F.
1883	Oct. 10	Austria, Olmutz, Stephanau I F.
1883	Oct. 15	Greece and Asia Minor, Syra, Chios, Smyrna, *Avalik* and villages between *Vurla* and *Chesmeh*, 3,000 houses destroyed III F.
1883	Nov. 1	Asia Minor, Island of Klazomena near Smyrna, Karatoi, Purgi III F.
1883	Nov. 3	Asia Minor, Karakoyunli, 30 miles from Erivan II M. & O.
1883	Nov. 14	Russian Turkestan, Tashkent and Osh in Fergana I M. & O.
1883	Nov. 18-24	Russia, Sultanabad, 20 miles from Osh and Osh II M. & O.
1883	Nov. 25	9h. 16m., p.m. Moluccas, *Saparoea* and other places in Amboina II O.N.T.
1883	Dec. 2 or Jan 2, 1884	Asia Minor, Sadikli near Brussa I F. & Ti.
1883	Dec. 22	Portugal I Ti.
1883	Dec. 26	Bosnia, Zepce I Ti.
1884	Jan. 10	9th, 23h. 22m., G.M.T. Philippines, S.E. Luzon (Camarines), Nueva Caceres II S.M.
1884	Jan. 23	Asia Minor (Kostambul or Kastamuni), Ka'adjik I F.
1884	Jan. 26	China (Yunnan), Tali Fu II M. & O.
1884	Jan.	Formosa, Unrin I H.
1884	Feb. 10	Asia Minor, Bitlis, Biroart II F.
1884	Beginning of Mar.	Persian Gulf, Muskat, Nedjd III F.
1884	Mar. 6	Salvador, San Salvador I Mon.
1884	Mar. 24 & 27	Hungary (Salavonia), Diakovar I F.
1884	Mar. 29	Asia Minor, Sinope I Ti.
1884	April 22	England, Colchester I R.
1884	May 12	8h. 17m., p.m. Celebes, Gorontalo in Menado I O.N.T.
1884	May 13	Asia Minor, Panderma, Crevassa II F.
1884	May 19	Persian Gulf, Kishm Island III F.
1884	June	Formosa, Unrin II H.
1884	June 5	Philippines, N. Mindanao, *Misamis* I S.M.
1884	July 18	5h. 18m., p.m. Sumatra, *Manna* and Lais in (Benkoelen) II O.N.T.
1884	July 23	Egypt, Massowah in the Red Sea I F. Ti. gives July 20 III
1884	Aug. 10	U.S.A., Virginia to Vermont I Ti.
1884	Sept. 2	Austria, Neustadt, Vienna, Voslan I Ti.
1884	Sept. 12	Italy, Pontoglio (Brescia) I B.
1884	Sept. 18	U.S.A. and Canada, Windsor (Ontario), Grasslake (Michigan), Toledo (Ohio, Kentucky) I F.
1884	Oct. 15	Japan (Musashi) I N.
1884	Oct. 29	28th, 20h. 10m., G.M.T. Philippines, S. & S.E. Luzon (Laguna, Tayabas, Camarines, Albay, Sorsogon) and Masbate Island I S.M.
1884	Nov. 2	Iceland, Tingeyjarsyslu, Husavik, some houses slightly damaged I Th.
1884	Nov. 5	Panama, Aquadaloe, Pacoria II Mon. & F.
1884	Nov. 6	Colombia, Cali II F.
1884	Nov. 26	Bolivia I Mon.
1884	Nov. 27	France and Italy, most destructive in Briançon, France; Cesana, Melegnate and other places in (Piedmont) I B.
1884	Dec. 10	Caucasia, Shusha I M. & O.
1884	Dec. 24	23rd, 21h., G.M.T. , Philippines (Samar, Leyte and N.E. Mindanao) I S.M.
1884	Dec. 25-27	Spain (Malaga and Granada), *Alhama*, *Malaga*, Seville; 40-50 towns damaged III F.
1884	Dec, 30	Spain, Granada I F. Continuation of Dec. 25.
1884	Dec. 31	Spain, Valez, Torrox, Albuneulas II F. Continuation of Dec. 25.
1885	Jan. 1	Spain, Velez, Nerja, Torrox II F. Continuation of Dec. 25, 1884.

A.D.		
1885	Jan. 4	Austria (S. Styria) I Ti.
1885	Jan. 5	Spain (Andalusia), Nerja, Trijlliano II F.
1885	Jan. 12	Spain, Malaga and Granada I F.
1885	Jan. 12	Siberia, Villages of Kabansk and Bargusinsk, east of Lake Baikal I M. & O.
1885	Jan. 14	China (Shensi), *Chishan* in Fengsiang Fu III Ho.
1885	Jan. 15	India, Cashmere, Srinagar I N.
1885	Jan. 24	Italy, Porto Maurizio (Liguria) I B.
1885	Jan. 25	Iceland, Northland, Kelduhverfi, many houses damaged III Th.
1885	Jan. 27	Spain, Tejede, boundaries of (Malaga and Granada) II F.
1885	Jan. 29	Spain (Andalusia), Montril, Alhama I F.
1885	Jan. 31	Algeria, Msila II Ti.
1885	Feb. 8	Spain, Malaga, Meluna I F.
1885	Feb. 12	3h. 8m., a.m. Java, *Wonogiri* and elsewhere in Soerakarta and over most of Java I O.N.T.
1885	Feb. 13	Spain, Torre del Campo II F.
1885	Feb. 21	Spain (Andalusia), Loja and Alhama II F.
1885	Feb. 22	7h. 30m., G.M.T. Philippines, E. Mindanao, along the Pacific Coast (Surigao), Bislig, Caraga II S.M.
1885	Mar. 6	Germany, Triberg, Schonwald I F.
1885	Mar. 27	Greece (Peloponnes), *Argos*, *Khelmos*, Missolunghi, Megalopolis, Corinth, Patras III F.
1885	April 5 & 6	Spain (Malaga), Velez, Antequera II F.
1885	April 9	France, Dôme II Ti.
1885	April 13	Switzerland from Genoa to Valley de Joux, Neuchâtel, Interlaken, *Simmenthal* I F.
1885	April 19	Spain (Malaga), Andalusia, Villanuova I F.
1885	April 30	5h. 53m., a.m. Moluccas, *Kajelie* and other places in Amboina III O.N.T.
1885	May 1	Austria (Styria), Valley of Murz, Mur, Murzsteg, Ottensheim, Leoben, Mittersdorf, Wartberg I F.
1885	May 3	11h. 20m., p.m. Java, *Java's 1st Point* in (Batam, Batavia and Preanger) I O.N.T.
1885	Middle of May	Central Asia, Village of Sikukh ? Kusitch, N.W. of Derbent II M. & O.
1885	May 30	India, Cashmere, Sopor, Musaserabad, 2,000 lives lost, Srinagar III O.D.
1885	Beginning of June	Caucasia, Sikutch ? Kusitch, N.W. of Derbent III F.
1885	June 6	India, Cashmere, Dubgaon, Jamalapor, Ovan III F.
1885	Middle of June	Russia, Village of Shishkina, 33 miles from Orenburg II M. & O.
1885	June 17	Italy, *Morro Realino*, Rivodutri, Riete and elsewhere in (Sabina) I B.
1885	June 20	West Switzerland (Vaud), Payerne, Neuchâtel, Yverdon I F.
1885	July 1	Italy, Vernante (Cuneo) I B.
1885	July 14	India, East and Middle Bengal, *Bogra*, *Dacca*, *Azimganj*, Calcutta, *Akeripare ?* Alipore II F.
1885	July 23	14h. 45m., G.M.T. Philippines, N.E. Mindanao, Dapitan district III S.M.
1885	July 24	India, Rungapur, *Nattore* and Bengal II F.
1885	Aug. 2	Russian Turkestan, *Belovodsk*, Karabalti, Tashkent, *Pischpek*, *Sukuluk* to Verny and Ilisk III M. & O. & F.
1885	Aug. 3	Mexico, *Tehuantepec*, Oaxaca, Morelos I O.B.
1885	Aug. 26	Austria (Styria), Valley of Mürz I F.
1885	Sept. 13	Midday. Java, Edam Island in (Batavia) I O.N.T.
1885	Sept. 17	Italy, Benevento and neighbourhood I B.
1885	Sept. 30	29th, 2h., G.M.T. Philippines, N. Mindanao, S.E. Leyte I S.M.
1885	Sept.-Oct.	Italy, Nicolosi near Etna I B.
1885	Oct. 9-25	Russian Turkestan, Tokmak district, 42°50N. 75°25E., Semirechie I M. & O.
1885	Oct. 30	Japan, Northern Japan I N.
1885	Nov. 5	6h. 3m., a.m. Java, Tjipanes (Preanger, Bantam, Batavia), Krawang and (Semarang) I O.N.T.
1885	Nov. 17	6h. 55m., a.m. West Indies, Trinidad I O.D.
1885	Nov. 19	U.S.A., California, San Francisco, 1 to 8 p.m., with sea waves I N.

A.D.		
1885	Nov. 19	13h. 31m., G.M.T. Philippines, N. Luzon (Nueva Vizcaya, Isabela), Bayombong, Ilagan II S.M.
1885	Nov. 22	Guatemala, Amatitlan II Mon.
1885	Nov.	Spain (Malaga), Velez, Malaga (Andalusia) and opposite African Coast I N.
1885	Dec. 2	Asia Minor, Karahsisar, Kemer I N.
1885	Dec. 3-13	Algeria, *M'Sila*, *Mascara*, *Blidah*, Bou Saada, *Médéa*, Bourunda and Setif III F.
1885	Dec. 13	Asia Minor, Aidin, Denizlu I N.
1885	Dec. 18	Guatemala, Guatemala, Amatitlan III F. & Ti.
1885	Dec. 26	Italy, Molise I B.
1886	Jan. 4	Russia, Tchembar, Penza Govt. I M. & O.
1886	Jan. 8-9	Greece, Roumelia I N.
1886	Jan. 18	Guatemala, Amatitlan, 131 shocks III N.
1886	Jan. 23	Hungary (Croatia), Jaska and Samobor I N.
1886	Jan. 29	Spain, Velez, Malaga I Ti. & N.
1886	Jan. 29	Algeria, Setif I N.
1886	Feb.-July	Italy (Calabria) I B.
1886	Mar. 14	Spain (Granada) I N.
1886	April 10	0h. 0m., G.M.T. Philippines. S.E. Panay, N.W. Negros Island I S.M.
1886	May 7	1h. 45m., a.m., and May 17, 3h. 53m., a.m. West Indies, Trinidad I O.D.
1886	May-July	Italy, Eastern flank of Etna, connected with an eruption I B.
1886	June 27	Caucasia, Shemaka I M. & O.
1886	July 6	Spain (Malaga) I Ti.
1886	July 23	Japan (S. Echigo, N.E. Shinano) I Mi.
1886	Aug. 15 to end of Sept.	Malta I O.D.
1886	Aug. 27	Midnight. Greece, Ionian Islands, S.W. Peloponnesus, Dept. of Messenia, Filiatra, Gargaliano, Marathupolis, also all Italy, Egypt, Malta and Syria III N., B., & O.D.
1886	Aug. 31	Friendly Islands, Niua-Fu Island I N.
1886	Aug. 31	U.S.A. (S. Carolina), Charlestown and Summerville III Ti. & F.R.
1886	Sept. 5	Italy, Coazze, Pinasca, throughout (Piedmont) and adjoining part of (Lombardy) I B.
1886	Sept. 22	3h. 3m., a.m. Java, Sinagar, elsewhere in the (Preanger, Bantam, Batavia) I O.N.T.
1886	Sept. 26	Asia Minor, Smyrna I Ti.
1886	Oct. 20	India, Cashmere, Srinagar I Ti. & N.
1886	Oct. 20	4h. 30m., p.m. 64°W. 19°N., sea-quake I N.
1886	Oct. 22	U.S.A., Charlestown, Savannah, Summerville I N.
1886	Oct. 31	Servia, Cacak, Zablace II O.D.
1886	Nov. 8	Russian Turkestan, Tokmak and Verny I M. & O.
1886	Nov. 29	Russian Turkestan, Tashkent II M. & O.
1886	Dec. 4	Servia, Cacak, Zablace I O.D.
1886	Dec. 11	Asia Minor, Smyrna, Chios II N. & Ti.
1887	Jan. 6	North Africa, Tunis, Ejenel ? II Ti.
1887	Jan. 15	Japan (Sagami), Yokohama I N.
1887	Feb. 2	15h., G.M.T. Philippines, Panay Island, *Iloilo* (Antique and Capiz) III S.M.
1887	Feb. 23	Italy and France, *San Remo*, *Portomourizio* and along the west of (Liguria), Nice, Marseilles III Ti. & B.
1887	Mar. 24	13h. 14m., G.M.T. Philippines, S.E. Luzon (Camarines), *Nueva Caceres*, Duet II S.M.
1887	May 3	U.S.A. and Mexico (Arizona), *Bavispe*, *Opulo*, *Arispe* in Sonora, Chihuahua, Guerrero, and along all the eastern slope of the Sierra Madre III O.B.
1887	May 5	3h. 39m., p.m. West Indies, Trinidad I O.D.
1887	May 26	Italy, Iesi in Ancona and along the Adriatic Coast I B.
1887	May 29 & 30	Mexico, Ayutla, origin coast of San Marcos I Bo.
1887	June 9-28	Russian Turkestan, Verny, Sophiisk, Kopal, Gabrilovka, Oksuisk, Karakul, Prjevalski and Valley of the Ili III M. & O., Ti., & N.
1887	June 13	1h. 17m., p.m. Sumatra and Java, *Benkoelen*, Taloe and Batavia I O.N.T.
1887	June 20	Ecuador, Guayaquil I Ti.

A.D.		
1887	July 16	Caucasia, Batum, Ozurgeti and Kutais I M. & O.
1887	July 17	Asia Minor, Rhodes Island, Crete, Chios, Canea I N.
1887	July 17	Egypt, Cairo, Suakin, and Nile Valley I Ti.
1887	July 17	Crete and Rhodes I B.
1887	Aug. 2	0h. 20m., p.m. Ecuador, Cuenca III N.
1887	Aug. 5	Algeria, Laghouat I Ti.
1887	Aug. 28	Mexico, especially Chilpancingo (Guerrero, Morelos, Hildago) I O.B. & N.
1887	Sept. 9	Russian Turkestan, Verny II M. & O.
1887	Sept. 23	7h. a.m., also 9h. 10m., a.m., also Sept. 24-26. West Indies, Bahamas, Inagua Island, Haiti, Port de Paix III O.D.
1887	Sept. 23	Bolivia, Yacuiva I Mon.
1887	End of Sept.	Hungary, Temesvar I N.
1887	Oct. 2?	West Indies, Cuba, Santiago de Cuba II Ti.
1887	Oct. 4	Greece (Corinthia), Kiato, Xylo-Kastro II Ti.
1887	Oct. 16	West Indies, Hayti II Ti.
1887	Oct. 28	Iceland, Southland, Reykjavik I Th.
1887	Nov. 9	Italy, Forli, Rocca S. Casciano and around I B.
1887	Nov. 14	Austria (Carinthia and Styria) I N.
1887	Nov. 14	France, S. Saturnin, Cavaillon I Ti.
1887	Nov. 26	Mexico, *Pinal de Amoles* in Quarataro, San Luis Potosi, Hidalgo, Guanajuato I O.B.
1887	Nov. 28	Iceland, Southland, Reykjanes, some houses damaged I Th.
1887	Dec. 3	Italy, *Besignano*, Mongrasso, S. Sofia, and neighbourhood in (Cosenza) II B.
1887	Dec. 16	China (Yunnan), *Shihping* in Linan Fu III Ho.
1888	Jan. 8	Algeria I Ti. & N.
1888	Jan. 10	8h. 55m., a.m. West Indies (Grenada), St. George, Grenville, also Trinidad and Paria II N. & O.D.
1888	Jan. 14	China (Yunnan), Shihping; (Ssuchuan), Luchou III N.
1888	Jan. 27	26th, 19h. 45m., G.M.T. Philippines, E. Mindanao, centre Agusan River Valley I S.M.
1888	Feb. 25	Italy, Stromboli I B.
1888	Mar. 13 & 15	2h. 11m., a.m. Celebes, Gorontalo in (Menado) I O.N.T.
1888	April 2	Switzerland (Glarus), Linthal, Elm I N.
1888	April 12	Austria, Odenburg, Eisenstadt, Pottendorf I N.
1888	April	China (Yunnan), especially the towns Shipin, Chenshui and Peiyuangting III M. & O.
1888	May 7	Norway and Islands of Vaero and Rost I N.
1888	May 15	Caucasia, Erivan I M. & O.
1888	May 24 to June 2	May 30th at 6 a.m. and June 2nd at 4.30 p.m. Dutch East Indies, Boeleleng in Bali II O.N.T.
1888	June 13	North China, Chefoo, Tientsin, Newchang II Ti.
1888	July 8	Italy, Teramo in the Abruzzi I B.
1888	July 14	Honduras, earthquake and storm I N.
1888	Aug.-Sept.	Italy, S. Lorenzo, Nuovo (Viterbo) I B.
1888	Aug. 19	6h. 30m., G.M.T. Philippines, N.E. Luzon (Cagayan, Isabela) I S.M.
1888	Aug. 21	8h. 32m. p.m. Sumatra, Solok and Loeboe Selassi in the Padangsche Bovenland I O.N.T.
1888	Sept. 1	New Zealand, North Canterbury, Amuri, Christchurch I Ti. & O.D.
1888	Sept. 1	Mexico, *Tetzilacatlan* in (Guerrero, Mexico, Morelos, Tlaxcala) I O.B.
1888	Sept. 9	Greece III Ti.
1888	Sept. 16	Russian Turkestan, Verny and Pischpek I M. & O.
1888	Sept. 22, 23-26	Armenia, Ardahan, Okan II M. & O.
1888	Sept. 27	Evening. Java, Keraugpandon in Soerakarta I O.N.T.
1888	Oct. 7	Mexico, Papantla and elsewhere in Vera Cruz I O.B.
1888	Oct. 10	India (Burmah), Rangoon I O.D. & Ti.
1888	Nov. 10	Bosnia, Stolac I Ti.
1888	Nov. 28	Russian Turkestan, Tashkent, Kojent and places east of Tashkent I M. & O.
1888	Nov. 29 & Dec. 8	Russian Turkestan, Verny and Kopal I M. & O.
1888	Dec. 20	Costa Rica, San José, Alajuela II Ti.
1888	Dec. 23	India, Calcutta I N.

A.D.		
1888	Dec. 28	Baluchistan, Quetta II N.
1888	Dec. 30	1h. 21m., a.m., local. Costa Rica, San José, Alajuela, Heredia III N. & O.D.
1888		Formosa, Unrin II H.
1889	Jan. 1	2h. 20m., G.M.T. Philippines, N.E. Mindanao (Surigao, Butuan) II S.M.
1889	Jan. 11	Greece, Sparta III N. Ti. gives Jan. 17.
1889	Feb. 5	7h. 53m., G.M.T. Philippines, W. Mindanao (Zamboanga), Basilan Island (Cotabato and Lanao), epicentre south of Illana Bay II S.M.
1889	Feb. 13	France and Switzerland, Fleurier, Jura Mountains II N.
1889	Feb. 18	France, Isère, Pont de Beauvoisin I N.
1889	Feb. 18	Japan, Tokio, Yokohama, (Sagami, Musashi, Shimosa, Kazusa and Awa) I Mi.
1889	Feb. 25	Russian Turkestan, Verny I N.
1889	April 5	Gold Coast, Accra, Aburi I N.
1889	May 26	25th, 18h. 23m.,G.M.T. Philippines, S. Luzon (Batangas), and N. part of Mindoro, Taal, Ibaan, Calapan II S.M.
1889	May 30	France, Cherbourg I Ti.
1889	June 13	China (Shantung), Yenchou Fu; (Chihli), Paoting Fu, Hochien Fu, Tiensin Fu II Ho.
1889	June-Oct.	Italy, Tolmezzo, Caneva, and neighbourhood in (Udine) I B.
1889	July 12	Russian Turkestan, Djarkend or Dsharkent, Prjevalsk or Prshewalsk III N.
1889	July 19	U.S.A., Tennessee, Memphis I F.R.
1889	July 19	10h. 42m., a.m. Moluccas, Batjan in Ternate I O.N.T.
1889	July 28	Japan, Kyushu, part of Shikoku (Higo) *Kumamoto* III O.
1889	Aug. 17	Bosnia, Mostar, Ostrojac or Ostrosatz, Konjica I N. Ti. gives 16th.
1889	Aug. 17	Mexico, Teloloapan (Guerrero) II O.D.
1889	Aug. 26	Greece, round the Gulf of Corinth II Ti. & N.
1889	Aug. 27	U.S.A., California, Los Angeles, Pasadena I Ti.
1889	Sept. 4	7h. 37m., p.m. Java, Rendang in Japara II O.N.T.
1889	Sept. 6	12h. 43m., a.m. Celebes and Moluccas (Na Lewet) and Minahassa in Menado and Batjan in Ternate I O.N.T.
1889	Sept. 18	7h. 8m., a.m. Java, *Bondowoso* and other places in Besoeki I O.N.T.
1889	Oct. 6	3h. 10m., G.M.T. Philippines, E. Mindanao, Davao district, epicentre in the Valley of the Agusan River II S.M.
1889	Oct. 13	Iceland, Reykjanes Peninsula, a few houses damaged I Th.
1889	Oct. 23	Mexico (Guerrero), Coahuayutla I O.D.
1889	Oct. 25	Turkey, Dardanelles I Ti.
1889	Oct. 28	9h. 45m., a.m. Asia Minor, *Mitylene*, Sigri Lighthouse II N.
1889	Nov. 19	Russian Turkestan, N.E. Shores of Lake Issyk-kul, Uital, Saizewka, District of (Verny); shocks until Dec. III N.
1889	Nov. 28	Italy, Acciano in the Abruzzi I B.
1889	Dec. 1	Servia, Kragojevatz, Jagodina, Kupsia? Kuprija and Paracin I Ti.
1889	Dec. 8	Italy, Vico, Cagnano Varano, etc., in the Gargano Peninsula and the neighbouring coast of (Apulia) I B.
1889	Dec. 12-13	Italy, Sicily, Zafferana and Acireale on the S.E. flank of Etna I B.
1890	Feb. 7	6th, 16h. 10m., G.M.T. Philippines (N. Leyte), Carigara, Barugo and other towns II S.M.
1890	Feb. 24	Canada, Queen Charlotte Islands, Skeena II N.
1890	Mar. 26	Italy, Longarone and environs in (Belluno) I B.
1890	April 13	6h. 4m., G.M.T. Philippines, N. Luzon (Ilocos Norte and Sur, Mountain Province, Cagayan, Isabela) I S.M.
1890	April 24	Peru? San Felipe I Mon.
1890	May 20	Asia Minor, Kayi, Refahie III Ti.
1890	May 24-25	Italy, S.E. of Pantelleria Island I B.
1890	May 26	Armenia, Village of Kayi, District of Refahie II N.

A.D.		
1890	June 2	Peru, Lima I Ti.
1890	June 20	7h. 37m., a.m. Java, *Wonogiri* in (Soerakarta) and over West Java I O.N.T.
1890	June 28	Persia, between Meshed and Teheran, Tasch II N.
1890	Oct. 4	1h. 19m., p.m. Java, Tjitjalengka and elsewhere in the (Preanger) I O.N.T.
1890	Oct. 5	2h. 31m., a.m. West Indies, Trinidad I O.D.
1890	Nov. 15	5h. 30m., p.m. Scotland, Inverness I N.
1890	Nov. 20	4h. 30m., a.m. West Indies, Trinidad I O.D.
1890	Nov. 23	Between 9h. 50m. and 10h. 20m., a.m. Moluccas, Banda-Neira in Amboina I O.N.T.
1890	Nov. 28	Hungary, Pressburg I Ti.
1890	Dec. 3	Mexico II Ti.
1890	Dec. 12	7h. 50m., a.m. Java, *Djoewana* in Japara and over great part of Java II O.N.T.
1891	Jan. 2	U.S.A., North California I N.
1891	Jan. 8	U.S.A., Texas, Rusk I Ti.
1891	Jan. 15	4h., local. Algeria, Gouraya, Villebourg, Philippeville, Blidah III N. Ti. gives II
1891	April 3	Armenia, Van, Adeljiwaz III Ti.
1891	April 30	11h. 30m., p.m. Java, *Gombong* in Bagelen, (Cheribon, Preanger and Semarang) I O.N.T.
1891	May 5	1h. 22m., p.m. Java, *Wonogiri* in Soerakarta and *Toeloeng Agoeng* in (Kediri) I O.N.T.
1891	June 7	Italy, Tregnano, Badia Calavena and neighbourhood in (Verona), felt over all North Italy and in Trieste II B.
1891	June 17 or 18	India, Bengal, Serajgunj, Dhamra I N. & Ti.
1891	June 25	12h. 10m., G.M.T. Philippines, E. Mindanao (Butuan and Davao) districts; centre in Agusan River Valley II S.M.
1891	June 29	U.S.A., California, San José I N.
1891	July 26	U.S.A., Indiana, Evansville I N.
1891	Aug. 1	Italy, Lugo in (Romagna) I B.
1891	Aug. 15	Central Bolivia I Mon.
1891	Sept. 9	1h. 55m., a.m. Salvador, San Salvador, Comasagua, Analquito, Santa Tecla, San Pedro III N.
1891	Oct. 1	Italy, Montecassino in (Caserta) I B.
1891	Oct. 6	Italy (Perugia), Sellano I B.
1891	Oct. 11	U.S.A., California, Napa I N.
1891	Oct. 14-26	Italy, Pantellaria Island; submarine with volcanic eruption I N. & B.
1891	Oct. 28	Japan (Mino, Owari) III O.
1891	Dec. 22	Italy, Sondrio and neighbourhood in (Lombardy) I B.
1892	Jan. 6	Italy, Campazzi, Salo in the basin of Lake Garda I B.
1892	Jan.	Tasmania I Ti.
1892	Mar. 8	Philippines, Batanes Islands, *San Domingo* and other towns on Batan Island II S.M.
1892	Mar. 16	Italy, Alicuri, Filiduri, Saliva, Lipari Islands and felt in Sicily and (Calabria) II B.
1892	Mar. 16	12h. 58m., G.M.T. Philippines, N. Luzon (Pangasinan, Union and Abra provinces); reported at 16h. 34m. on same day, also on the 26th and 28th III S.M.
1892	April 17	U.S.A. (Oregon), Portland I Ti.
1892	April 19-21	U.S.A. (California), Oakville, Winters, Dixon, San Francisco I N. & Ti.
1892	April 22	Formosa, Anpin I H.
1892	April-June	Italy, Peninsula Garganica in (Apulia) I B.
1892	May 16	Philippines, Guam in the Ladrones II S.M.
1892	May 17	Italy (Emilia), Carpineti I B.
1892	May 17	1h. 18m., p.m. Sumatra, Padang, Sidempoean in Tapanoeli (Benkoelen, Palembang) and east coast of Sumatra I O.N.T.
1892	June 24	Mexico, Guadalajara II N.
1892	June 24	Italy, Claut and neighbourhood in (Udine) I B.
1892	June 30	Italy, Badia Calavena and Valli dei Signori in (Verona) and parts of (Vicenza) I B.
1892	July 7	Italy, Sicily, Zafferana, Calanna, etc., near Etna I B.
1892	Aug. 4 ?	Central America ? San Cristobal ? III Ti.
1892	Aug. 9	Italy, Badia Calavena, Chiampo, etc., in (Verona) I B.

A.D.		
1892	Sept. 29	Spain, Huelva I N. & Ti.
1892	Oct. 14	Roumania, Bucharest, Olteniza I N. & Ti.
1892	Nov. 21	Italy (Perugia), Fracceano, Cafirenze, etc., near Citta di Castello I B.
1892	Dec. 9	Japan, West of part (Noto) II O.
1892	Dec. 20	0h. 20m., G.M.T. Baluchistan, Shalabagh, Sanzal, Old Chaman III N.
1892-3	Dec. 29 to Jan. 9	Italy, Castel del Rio, Monzuno, etc., in (Romagna) I B.
1893	Jan. 25	Italy, Salerno and neighbouring parts of (Basilicata) I B.
1893	Jan. 31-Feb. 3	Greece, Zante, also at Patras III N. & Ti.
1893	Feb. 12	New Zealand, Wellington, Nelson I N. & O.D.
1893	Feb. 13	Baluchistan, Quetta II N.
1893	Feb.	Turkey, Samothraki Island III N.
1893	Mar. 9	8th, 16h. 35m., G.M.T. Philippines, Central Luzon (Nueva Vizcaya, Abra, Pangasinan) I S.M.
1893	April 8	Servia, Belgrade, Morava Valley, Pozarevac, Svilajnac, Gradiste II N. Ti. gives April 10 and III
1893	April 12	5h. 48m., G.M.T. Philippines (Camarines, Albay, Sorsogon, Masbate) and North Samas I S.M.
1893	April 17	5h. 29m., Greece, Zante, also at Patras III N. & O.D.
1893	April 19	10h. 40m., p.m. Dutch East Indies, Boeleleng in Bali I O.N.T.
1893	April 22	Italy, S. Piero Patti, S. Barbora and Monte Albano Elicona (in Messina) I B.
1893	May 20 & 31	Servia, Morava Valley I O.D.
1893	June 3	2nd, 22h. 23m., G.M.T. Philippines, W. Mindanao, Illana Bay II S.M.
1893	June 11	8h. 17m., a.m. Sumatra, Tebing, Tinggi in Palembang II O.N.T.
1893	June 12	7h. 57m., a.m. Sumatra, *Manna, Kauer* (Benkoolen), Lampong, Palembang III O.N.T.
1893	June 14	Austria, Chimara, Kuc in Epirus I B.
1893	June 21	6h. 50m., G.M.T. Philippines, E. Mindanao, Agusan River Valley III S.M.
1893	July 1	June 30, 2h. 8m., G.M.T. Philippines, E. Mindanao, Agusan River Valley II S.M.
1893	Aug. 2	Italy, Montereale in (Aquila) I B.
1893	Aug. 5	Austria, Styria, Mur Valley II N.
1893	Aug. 10	Italy, Mattinata and Southern shore of the Peninsula Garganica II B.
1893	Sept. 6	Shocks until Nov. China (Yunnan), Linan Fu I Ho.
1893	Sept. 7	Japan, Kagoshima III O.
1893	Sept. 8	Servia, Morava Valley II O.D.
1893	Oct. 27	Italy, *Longarone*, Farra di Alpago and neighbourhood (Belluno) I B.
1893	Nov. 5	India (Punjab), Peshawar, Naushara I N.
1893	Nov. 14	8h. 55m. Greece, Salamis I O.D.
1893	Nov. 17	8h. 23m., a.m. Russian Turkestan, Kassan, Samarkand III N. & Ti.
1893	Nov. 27	Canada, Montreal I N. & Ti.
1893	Dec. 24	23rd, 16h. 24m., G.M.T. Philippines, S.E. Luzon, North Samar, N.E. *Masbate Island* I S.M.
1894	Feb. 9	Italy, Bosco Chiesa, Velo Veloncse, etc., between the Adige and the Chiampo Brook (Verona) I B.
1894	Feb. 10	9th, 16h. 42m., G.M.T. Philippines, S.E. Mindanao. East Davao Gulf II S.M.
1894	Feb. 18	17th, 21h. 23m., G.M.T. Philippines, Mindanao, Agusan River Valley I S.M.
1894	Mar. 16	Italy, Pantellaria I B.
1894	Mar. 22	Japan, Yezo, (Kushiro, Nemuro) II O.
1894	Mar. 26	Italy, Lesina (Foggia) I B.
1894	April 2	1st, 18h. 34m., G.M.T. Philippines, Central Luzon (Nueva Ecija, Pangasinan, Benguet) I S.M.
1894	April 20	Colombia and Venezuela, Cucuta, Maracaibo I Ti.
1894	April 27	Greece, district between Thebes, Lividia, Atlanta and Chalcis III O.D. N. gives April 20 and May 1.
1894	April 27	Evening, Java, Panaroekan and elsewhere in (Besoeki) I O.N.T.

A.D.		
1894	April 28	Venezuela, Meriòda II O.D.
1894	May 21	New Zealand, Wellington, Nelson, Christchurch I N.
1894	May 28	Italy, *Viggianello*, Rotonda, Castelluccio and neighbourhood (Basilicata) I B.
1894	June 19	Algeria, Oran I N. & Ti.
1894	June 19	6h. 56m., p.m. Java, Besoeki I O.N.T.
1894	June 20	Japan, Tokio I O.
1894	June 29	28th, 18h. 57m., G.M.T. Philippines, E. Mindanao, Agusan River Valley II S.M.
1894	June 30	29th, 21h. 50m., G.M.T. Philippines, E. Mindanao, Agusan River Valley II S.M.
1894	July 4	4h. 15m., p.m. Java, Besoeki I O.N.T.
1894	July 10	Turkey, Constantinople, Pera, S. Stefano, Tchataldcha to Ada-bazar along the Gulf of Ismid, Island of Chalki and Antigoni III N. & Ti.
1894	July 18	U.S.A. (Utah), Ogden I F.R.
1894	July 26	0h. 35m. Greece, Douka (Elis) I O.D.
1894	July 26	Servia, Varna II Ti.
1894	Aug. 7-8	Italy, Fleri, Pisano, Scacchiere, Zerbate (Catania) II B.
1894	Sept. 2	Roumania, Bucharest and other Roumanian towns II Ti.
1894	Oct. 2	Prussia, Dortmund II Ti.
1894	Oct. 15	New Hebrides, Ambrym, with eruption I Ti.
1894	Oct. 20	9h. 21m., a.m. Sumatra, Manna (Benkoelen, Palembang) over west of Java II O.N.T.
1894	Oct. 22	Japan (Ugo), Shonai II O.
1894	Oct. 23	U.S.A., California, San Diego I F.R.
1894	Oct. 27	Argentina, La Rioja, San Juan, La Paz, Cordova and Rosario II Mon., N. & Ti.
1894	Nov.	Venezuela, Carache I O.D.
1894	Nov. 2	22h. 53m. Mexico, Mexico City I Pe.
1894	Nov. 16	Italy, especially between Palmi and S. Cristina on the north-western side of Aspromonti in (Calabria), felt over Eastern Sicily or South Italy II N. & B.
1894	Nov. 20	2h. 10m., a.m. Celebes, Tontoli I O.N.T.
1894	Nov. 27	Italy, Brescia and other places near the Lake of Isio I B.
1894	Nov 28	Italy, Fonzaso (Belluno) I B.
1894	Dec. 10	Servia, Morava Valley I O.D.
1894	Dec. 13 & 14	India, Burma, Rangoon II O.D.
1894	Dec. 19	10h. 35m., p.m. South Hungary (Kiasso), Oravica I N.
1894	Dec. 27	Italy, Island Filicuri in the Lipari Islands I B.
1894	Dec. 30	17h. 12m. or 31st, 5h. 12m. Mexico, Mexico City I Pe.
1895	Jan. 7 & 17	Persia (Khorasan), Kuchan, Meshed III N. & Ti.
1895	Feb. 27	Italy, Claut (Udine) and neighbourhood I B.
1895	Mar. 23	Italy, Comacchio, Ostellato (Ferrara) I B.
1895	April 13	Italy, Licodia and Vizzini in (Syracuse) and in (Catania) I B.
1895	April 14	Austria and Italy, from Gemona in (Friuli) to Venice and felt also in (Lombardy), centre at Lubiana in Austria I B., N., & Ti.
1895	May 1	Greece, Atalanta I Ti.
1895	May 13 or 14	Greece and Turkey (Albania), Paramythia, Dragani III Ti. & N.
1895	May 14	13th, 22h. 42m., G.M.T. Philippines, N. Mindoro, *Calapan* II S.M.
1895	May 20	West Indies, Antigua, Montserrat, Nevis, St. Kitts and Barbuda I N. O.D. gives May 29.
1895	May 20	Italy, Spoleto and neighbourhood I B.
1895	May 25	Italy, Crespino, Papozze and Rovigo (Ferrara) I B.
1895	June 7	13h. 56m., G.M.T. Philippines, N. Mindoro, *Calapan* II S.M.
1895	June 10	Italy, Follino and Valmareno in Treviso I B.
1895	Aug. 9	Italy, Island of Kremiti, Chietino (Apulia) I B.
1895	Aug. 18	New Zealand, Taupo II Ti.
1895	Aug. 19	Peru, Chincha Island II Ti.
1895	Sept. 4	Italy, Querciolano (Tuscany) I B.
1895	Oct. 25	Italy, Poggibonsi and neighbourhood in (Siena) I B.
1895	Nov. 1	Italy, Rome and country towards the sea I B.
1895	Dec. 25	Spain (Orense, Galicia) I N.
1896	Jan. 2	Persia, Khalkhal, North of Mianeh, Goi, Gangabâd III N. & Ti.

A.D.		
1896	Mar. 2	Mexico (Jalisco), Colima, San Gabriel and many other places I O.D.
1896	Mar. 12	Russia, Odessa I Ti.
1896	Mar. 12	Roumania, Jassy and Neamtu (Avramesei) I O.D.
1896	Mar. 14	1h. 16m. Chile, Santiago and Valparaiso II Ti. & Mon.
1896	Mar. 18	Italy, Acireale (Catania) I B.
1896	April 17	Italy, Monte S. Angelo (Foggia) I B.
1896	April 18	Dutch East Indies, Alor in Timor III O.N.T.
1896	May	U.S.A., Alaska, Orca II F.R.
1896	June 15	N.E. Japan, Kamaishi, chiefly sea waves III O.
1896	June 29	Cyprus, Limasol III N. Ti. gives July 5.
1896	June 30	8h. 0m., p.m. Java, Sendoero in Probolinggo (Pasoerocan, Besoeki) I O.N.T.
1896	July 8-9	Italy, Granaglione (Bologna) I B.
1896	July 9	Russia, Caspian Sea I N.
1896	Aug. 15	4h. 40m., p.m. Java, *Patjitan* in Madioen and over the greater part of Java I O.N.T.
1896	Aug. 19	6h. 18m., p.m. Java. *Toeloeng Agoeng* and elsewhere in (Kediri) I O.N.T
1896	Aug. 26	Iceland, Arnessysla, Rangarvallasysla, Faxafloi, many hundred farms and over 2,000 cattle-sheds fell and more damaged III Th.
1896	Aug. 31	Japan (Uzen, Ugo). Akita, Rokugo II O.
1896	Sept. 6	Iceland II N.
1896	Sept. 13	4h. 56m., G.M.T. Philippines, N.W. Luzon (Ilocos Norte, Mountain, Cagayan), Laoag, Aparri I S.M.
1896	Oct. 16	Italy, San Remo, Oneglia and other places in Western (Liguria) I B.
1896	Nov. 2	11h. 59m., a.m. Java, *Pameungpeuk*, *Boengboelang* in the (Preanger, Batavia, Cheribon, Kedoe, Banjoemas, Semarang, Kediri), Bagelen I O.N.T.
1896	Nov. 13 & 14	Asia Minor, Aidin, Bergama I N.
1896	Dec. 1	Italy, Pontebba (Udine) I B.
1896	Dec. 17	5h. 30m., a.m. England, Hereford I N.
1896	Dec. 29	4h. 51m. Greece, Yannitsa or Calamata I O.D.
1897	Jan. 6, 7, & 19	Italy, Vallo di Nera, Spello and other places in (Umbria) I B.
1897	Jan. 11	Persia, Kishm II Ti. & N.
1897	Jan. 17	Japan (Shinano), Nagano III O.
1897	Jan. 17	Turkey, Epirus, Delvino II Ti. & N.
1897	Jan. 18	17th, 18h. 35m., G.M.T. Philippines, N. Luzon (Mountain, Isabela, Cagayan) I S.M.
1897	Feb. 15	Servia, Vranji, Mostanica, Ristobac II O.D.
1897	Feb. 16	15th, 21h. 4m., G.M.T. Philippines, E. Mindanao, Agusan River Valley II S.M.
1897	Feb. 20	Japan, Sendia III O.
1897	Mar. 15	Celebes, the Island Kajoewadi I O.N.T.
1897	April 8	13h. 20m., G.M.T. Philippines, E. Mindanao, Agusan River Valley II S.M.
1897	April 29	West Indies, Guadeloupe (Pointe à Pitre), Antigua, St. Kitts, Dominica II N. & O.D.
1897	May 3	North Coast of Iceland I Th.
1897	May 10	S. Australia, Kingston, Robi, Beachport I O.D.
1897	May 13	11h. 22m., G.M.T. Philippines, Masbate and neighbouring Islands II S.M.
1897	May 15	Italy, N.W. Sicily and Ustica Island I B.
1897	May 28	Italy, S.E. Sicily, Terra d'Otranto and South Italy, felt over most of the Peninsula ; most violent in Greece I B.
1897	June 5	Mexico (Oaxaca), Juchitan I O.D.
1897	June 12	11h. 5m., G.M.T. India, Calcutta, Assam, *Shillong*, *Gauhati*, Goalpara, Dhubri III N. & Ti.
1897	July 15	Austria, Laibach I N.
1897	July 27	Italy, *Ponsacco*, Pontedera (Pisa) I B.
1897	Aug. 15	12h. 17m., G.M.T. Philippines, N. Luzon (Ilocos Sur), *Candon* and *Vigan* II S.M.
1897	Aug. 29	Servia, Morava Valley I O.D.
1897	Sept. 18	Russian Turkestan, Samarkand, Tashkent I N. & Ti.
1897	Sept. 20	Peru, Liam, Matucana I N.
1897	Sept. 21	Italy, Sinigallia, Fano, Mondolfo (Ancona) I B.

A.D.		
1897	Sept. 21	20th, 19h. 10m., G.M.T. Philippines, N.W. Mindanao (Dapitan) district II S.M.
1897	Sept. 21	5h. 15m., G.M.T. Philippines, W. Mindanao, Sulu district (Basilan, Zamboanga), and Jolo Island; it caused the greatest sea tide ever recorded in the Philippines III S.M.
1897	Oct. 8	7th, 21h., G.M.T. Philippines, Davao I S.M.
1897	Oct. 19	9h. 5m., G.M.T. Philippines, N. Samar Island, Sulat, Palapag, Catubic, Oras, Laoang III S.M.
1897	Oct. 19	7h. 15m., G.M.T. Philippines, Visayas Island and N. Samar II S.M.
1897	Nov. 2	3h. 25m. Greece, Leukas or Santa Maura I O.D.
1897	Nov. 14	0h. 50m., G.M.T. Philippines, N. Luzon (Ilocos Sur), Vigan, *Candon* I S.M.
1897	Dec. 8	New Zealand, Wellington, Wanganui I O.D.
1897	Dec. 18	Italy, places North of C. di Castello (Umbria) I B.
1897-8	Dec. & Jan.	West Indies, Montserrat I O.D.
1898	Jan. 6	Moluccas II Ti.
1898	Jan. 30	11h. 15m., G.M.T. Philippines, W. Mindanao, Basilan, and Zamboanga district, Sulu Island II S.M.
1898	Feb. 15-20	West Indies, Montserrat I N.
1898	Feb. 28	Asia Minor, Balikesri II Ti.
1898	Mar. 4	West Indies I Ti.
1898	Mar. 4	Italy, the Apennines of Parma and Reggio and over North Italy I B.
1898	Mar. 30	U.S.A., California, Mare Island, San Francisco, Vallejo I F.R. & N.
1898	May 14	Italy, *S. Maria di Licodia*, Biancavilla (Catania) near Etna I B.
1898	June 2	22h. 5m., Greece (Arcadia), Tripolitza I B.
1898	June 20	Peru (Ica), Ica I H.J.
1898	June 28	Italy, *Rieti*, Cittaducale, Srufina (Umbria) I B.
1898	July 2	Hungary, Sinj in Dalmatia III B.
1898	July 23	Chile, Concepcion, Telcahuano I Mon.
1898	July 31	Hungary, Giannina in Epirus I B.
1898	Aug. 10	Japan (Chikuzen), Itoshimagori II O.
1898	Aug. 10	Italy, *Messina* and other places in Sicily and in Calabria I B.
1898	Aug. 25	Italy, in the villages round Visso (Macerata) I B.
1898	Sept.	China (Shansi), Taichou II "North China Herald"
1898	Nov. 2	11h. 23m., 11h. 37m., and 11h. 56m., p.m. Java, *Soekapoera*, *Tegnkadjang*, *Pakendjeng* and elsewhere in (Preanger) I O.N.T.
1898	Nov. 9	10h. 1m. Greece, Kyparissia I O.D.
1898	Nov. 20	5h. 46m., p.m. Moluccas, Saparoea in Amboina I O.N.T.
1899	Jan. 22	8h. 13m. S.W. coast of Greece (Peloponnese), Philiatra, *Kyparissia* III Ti.
1899	Jan. 24	Mexico, Chilpancingo and in the State of Puebla, Vera Cruz, Michoacan, Guerrero, Oaxaca I Ti. & O.D.
1899	Feb. 27	Iceland, Reykjanes Peninsula, Reykjavik, a few houses damaged I Th.
1899	Mar. 7	0h. 45m., G.M.T. Japan near Nagoya II Mi.
1899	Mar. 24	Salvador near San Vicente II O.D.
1899	April 12	Argentina, Rioja, Catamarca, Tucuman, Rio, Cuarto, Santiago del Estero I Mon.
1899	May 3	19h. 5m. Greece, Ligoudista I O.D.
1899	May 17	West Indies, Montserrat I Ti.
1899	July 19	Italy, Rome I Ti.
1899	Aug. 13	Portugal, Lisbon I Ti.
1899	Sept. 3-10	U.S.A., Alaska, Yakutat Bay III F.R.
1899	Sept. 20	Asia Minor, Aidin, Smyrna, Meander Valley III N.
1899	Sept. 25	India, Darjiling III ? Ti.
1899	Oct. 12	Moluccas, Ceram, Ambon III Ti.
1899	Oct. 29	Java, *Bengboelang* and elsewhere in (Preanger and Cheribon) I O.N.T.
1899	Dec. 25	U.S.A., S. California, San Jacinto, Riverside Co. I F.R.
1899	Dec. 26	25th, 20h. 20m., G.M.T. Philippines, Mindanao, Agusan River Valley I S.M.
1899	Dec. 31	Caucasia, Tiflis, Acalkalaki III N.

APPENDIX II.

Corresponding Societies Committee.—Report of the Committee, consisting of Mr. W. WHITAKER (*Chairman*), Mr. W. P. D. STEBBING (*Secretary*), Rev. J. O. BEVAN, Sir EDWARD BRABROOK, Dr. J. G. GARSON, Principal E. H. GRIFFITHS, Dr. A. C. HADDON, Mr. T. V. HOLMES, Mr. J. HOPKINSON, Mr. A. L. LEWIS, Mr. F. W. RUDLER, Rev. T. R. R. STEBBING, *and the* PRESIDENT *and* GENERAL OFFICERS. (*Drawn up by the Secretary.*)

THE Committee beg leave to recommend that the Cotteswold Naturalists' Field Club and the Sheffield Naturalists' Club be placed on the list of Affiliated Societies.

The Warrington Field Club reports that its membership has dropped below fifty, but the Committee recommend its continuance on the list of Associated Societies for the present as the fall below the statutory number may be only temporary.

The Committee recommend that the hour for meeting of the Conference of Delegates at Portsmouth be changed from 3 P.M. to 2 P.M.

The Committee report that while the price of the Geological Survey maps to the public has not been reduced, uncoloured copies of the maps printed with the boundary-lines of the formations may be purchased at the same price as the plain Ordnance Survey sheets.

Professor J. W. Gregory has promised to preside at the Conference of Delegates in Portsmouth, and to deliver an address.

Mr. F. Balfour Browne, of Belfast, will report on the findings of a committee of members of Sections D and K appointed to formulate a definite system on which collectors should record their captures.

The Committee recommend for discussion the following subjects, which have been suggested by the British Mycological Society and the Selborne Society: (1) The Study of Fungi by Local Natural History Societies: (2) The Protection of Plants. The delegates of these Societies will be present and will open the discussions.

The Committee ask to be reappointed, and, in consideration of the labour involved in the compilation of their catalogue of scientific papers, and the expenditure on the binding and upkeep of the collection of local societies' publications at the offices of the Association, apply for a grant of 25*l*.

Report of the Conference of Delegates of Corresponding Societies held at Portsmouth, August 31 and September 5, 1911.

Chairman . . . . . Professor J. W. Gregory.
Vice-Chairman . . . . . William Dale.
Secretary . . . . . . W. P. D. Stebbing.

FIRST MEETING, *August* 31.

The Secretary having read the report of the Corresponding Societies Committee, the Conference agreed that the grant of 25*l.* referred to therein should be applied for.

The Chairman then delivered his Address, entitled

The Scientific Misappropriation of Popular Terms.

ONE of the main functions of the British Association is to prevent the development of a scientific caste in this country. The essential ideas of caste and science are diametrically opposed; nevertheless, the spirit of caste has in times past invaded the spirit of science, with the natural consequence that the eager explorers of knowledge became the academic guardians of tradition; and the same invasion now would deprive science of the popular sympathy and support which are more than ever necessary for its steady development. The members of the Corresponding Societies have special opportunities for helping that part of the Association's mission, for their personal intercourse with all sections of the community enables them to do much 'to obtain a more general attention to the objects of science.' Their influence must be exerted mainly through words, and the proper use of words is a matter of vital importance to the welfare of science. The recent appeals for the improvement of the language of scientific literature are therefore direct contributions to scientific method; and as the Societies represented at this Conference are the strongest link between the technical specialist and those who take a friendly interest in science, special sympathy may be expected here with the complaints against the unintelligibility of some scientific writings owing to the excessive use of technical terms. I wish this afternoon, without denying that technical terms are sometimes used unnecessarily, to call attention to a more neglected and insidious evil, the use of well-known English words with a technical meaning. The temptation to adopt an old word for a new idea, instead of inventing a fresh term, is often strong. It saves trouble, at the time. The old word is probably shorter than a new one would have to be, and its use avoids burdening a passage with an unknown and perhaps uncouth term. A sentence in which all the words are familiar appears to present no difficulties; a reader skims lightly over it, pleased with the lucidity of the author and ignorant of the fact that it has been misunderstood, as the leading word conveyed to him a meaning different from that intended by the writer. The danger of a passage being misunderstood is more serious than that of its being not understood. It is worse to be misled by a plausible phrase than to be startled or repelled by a correct technical statement. A new word compels a conscientious reader to determine its true meaning, and should help him to a clear conception of the fresh idea; whereas the use of an old word with a new meaning discourages inquiry and encourages slovenliness in work and thought. The use of popular phraseology may render scientific literature apparently less strange; but if that phraseology be incorrectly used, the ultimate effect is to increase the divergence between the scientific and popular languages and the estrangement between science and public opinion. For the scientific use of terms inconsistently with their ordinary meanings is apt to persuade the layman that the language of science is so different from his own that it is no use attempting to understand it.

Most sciences have adopted popular terms with new and restricted meanings; and if the origin of such a word be forgotten, scientific writers are apt to treat any use of it in its original sense as a popular blunder. For example, zoologists not only now reject spiders from the class of Insecta but treat the idea that a

spider is an insect as a mistake due to simple ignorance. Thus, to quote a recent standard work, J. H. and A. B. Comstock in their 'Manual for the Study of Insects' (1909, p. 12), remark that spiders 'are often mistaken for insects,' although the authors have abandoned 'Insecta' as the name of the class in favour of Hexapoda. The word insect is much older than modern systematic zoology and the class Insecta. The word insect is derived from the Latin *insectum*, which is based on the verb *insecare*, 'to cut into'; and it was used for animals whose bodies are notched or incised into sections. This meaning of the word is well expressed in the definition by Philemon Holland, who is the earliest English author quoted in the 'New English Dictionary' as having used the word insect. In his book, 'The Historie of the World, commonly called the Naturall Historie of C. Plinius Secundus' (1601), he says, 'Well may they all be called Insecta, by reason of those cuts and divisions, which some have about the necke, and others in the breast and belly; the which do go round and part the members of the bodie, hanging together only by a little pipe and fistulous conveiance.'

The class Insecta was based by its founder, Linnæus, on the segmentation of the body, and not on the number of legs; it therefore included scorpions, millepedes, and spiders. It was not until half a century later that Lamarck excluded spiders from the class Insecta; and as late as 1863 we find so distinguished a naturalist as Bates [1] remarking that the spiders 'Mygales are quite common insects.' Even such a recent standard modern cyclopædia as the 'Jewish Encyclopædia' [2] retains the millepedes as insects. The term insect should not, however, be applied to a coral polyp; 'coral insect' is justly denounced as a misleading blunder, due to ignorance of the nature of the coral animal. The terms *insectum* and insect according to their original usage no doubt included worms, and Holland expressly mentioned earth-worms as insects. In many worms, however, the body is not divided into segments, and worms were therefore early and appropriately excluded from insects; so Milton writes [3] in his description of the bower in Eden:—

'Other creature here,
Beast, bird, insect, or worm, durst enter none.'

Johnson's Dictionary (first edition, 1755) accepted a definition restricting insects to animals whose body is nearly divided in the middle into two parts. 'Insects may be considered together as one great tribe of animals; they are called insects from a separation in the middle of their bodies whereby they are cut into two parts, which are joined together by a small ligature, as we see in wasps and common flies.' This definition, while admitting spiders, excluded worms. The present zoological separation of insects from other air-breathing arthropods is based mainly on the presence of six legs. The term Hexapoda is therefore more suitable for the class as now defined than Insecta; and the restriction of Insecta in systematic zoology to a group based not on the insection of the body but on the number of legs, is less accurate and appropriate than its previous use in zoology and in popular English. It would seem better to admit that the spider is an insect, but insist that it is not a hexapod.

The term worm, on the other hand, illustrates cases in which a restriction of popular meaning is both appropriate and convenient. A worm was originally not necessarily one of the Vermes of the zoologist. Thus the worms mentioned in the Old Testament included various insect larvæ. Dr. Ridewood tells me that the manna collected by the Israelites in the desert was probably a small lichen, and that the worms bred in it [4] were probably fly-grubs; and the references by Job and Isaiah to worms that cover the dead may include both insect-grubs and nematodes. When Job reminds the sinner of the worm that 'shall feed sweetly upon him' [5] he had in mind the larvæ of blow-flies; and though the worms that ate Herod [6] may have been endoparasitic worms or flukes, the worm that caused the withering of Jonah's gourd [7] was probably a beetle-larva.

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[1] *A Naturalist on the Amazon*, vol. i., p. 161.

[2] 1906, vol. vi., p. 105.

[3] *Paradise Lost*, iv.

[4] Exodus, xv., 20.

[5] Job, xxiv., 20.

[6] Acts, xii., 23.

[7] Jonah, iv., 7.

In popular English, moreover, worms always included snakes, as shown both by Dr. Johnson's definition of a worm, 'A small, harmless serpent that lives in the earth,' and by Shakespeare in Cleopatra's inquiry :—

'Hast thou the pretty worm of Nilus there,
That kills and pains not?'[8]

Uniformity between popular and zoological terminology can best be secured in regard to the term worm by inducing the public to use it only for one of the Vermes, for it is less necessary to have one term for all creeping things than to distinguish noxious snakes and centipedes from the lowly and useful worm.

The word fish illustrates how a popular word may become unduly extended and then be again restricted with fuller knowledge. The word is of very ancient origin, and was probably originally limited to what the zoologist accepts as fish. The term fish is not derived from the primitive Aryan language, and it was not introduced until the Latin-Teutonic section had separated from the Indian and the Greek; and as the term was invented by people who apparently had no knowledge of the sea, they doubtless used it for freshwater fish.[9] The primitive hunters who went to the coast may have extended it to shellfish, and it was adopted in the English crayfish by a corruption of the French *écrevisse.* When whales and dolphins were discovered, they were accepted as fish in ignorance of their affinities, for such aquatic animals as seals and otters were never included among fish, since their mammalian characters were obvious. That whales, porpoises, and their allies are not fish is now admitted in current language, though the old usage survives among whalers. The terms whale-fishery and seal-fishery are firmly established; but they are unobjectionable, because those industries have so many important features in common with the capture of fish. The general current limitation of fish to the fish of the zoologist is only a return to the primary meaning of the word.

Chemistry supplies an excellent illustration of the justifiable adoption of an old term with a revised meaning. Element is used in its classical meaning, though with a new interpretation; and Chaucer in 1386 shows that it was used in Early English in a similar sense. He says in the Frere's Tale (line 200) :—

'Make ye yow newe bodies alway
Of elementz.'

Its modern chemical use means the resurrection of the Lucretian word to a new period of usefulness.

The chemical adoption of the terms metal and non-metal for the two classes of elements is, on the other hand, an example of the inconvenience that results when a new definition is only approximately coincident with a well-established current meaning. The word metal appears to be derived from the Greek 'metallon,' connected with metallao, 'to seek after,' through the Latin *metallum,* a mine or quarry, or substance obtained by mining. Hence road-metal for stone is correct.

By the time of Johnson the word metal was usually restricted to those products from mines which have metallic as distinct from earthy or stony properties. Johnson's definition—'We understand by the term metal a firm, heavy, and hard substance, opake, fusible by fire, and concreting again when cold into a solid body such as it was before, which is malleable under the hammer, and is of a bright, glossy, and glittering substance where newly cut or broken,' states the general idea of a metal.

The chemical adoption of the word metal for the larger of the two classes of elements has resulted in its use in science with two contradictory senses; thus in elementary geology the word is used with its chemical meaning; but in economic geology in its commercial sense.

Sodium and potassium are therefore metals in elementary geology and academic mineralogy; but they are not metals in advanced economic geology. This double use of the word is an occasional source of confusion, and it dis-

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[8] *Antony and Cleopatra*, V. 2.

[9] See O. Schrader, *Prehistoric Antiquities of the Aryan Peoples*, 1890, pp. 117–118, 127–128, 353–354.

counts any good advice that may be given to students as to precision in the use of terms. It is perhaps too late to change, but it would have been better if the chemists had adopted technical terms for the two groups of elements, instead of applying the term metal to a material so unlike the ordinary idea of a metal as is sodium?

Geology has been a particularly flagrant sinner in the misuse of popular terms. Its nomenclature has not only unconsciously absorbed and modified many English words, but committees of experts have deliberately committed such wholesale piracy that our language has been left bankrupt in some departments. Thus terms are needed in stratigraphy for the various subdivisions of the sedimentary rocks and for the lengths of time occupied in their deposition. The International Geological Congress proposed the following series of terms, beginning with the larger divisions:—

Formation.	*Equivalent Time.*
Group	Era
System	Period
Series	Epoch
Stage	Age

Although this scheme of nomenclature would be very useful, it has not been generally adopted; and I think the reason is that, by assigning definite meanings to all the indefinite terms available, there is nothing left for use in an indefinite sense. Thus a number of beds which together may be either larger or smaller than a subdivision of a system, cannot be called a series without risk of misunderstanding. All the above eight terms are required for use in geology with their current English meanings. The scheme proposed by the International Geological Congress involves using these words sometimes in a technical and sometimes in a non-technical sense. In literature the difficulty may be overcome by printing the words with capital letters when they are used as the names of definite divisions; but that is impossible in speech. The principle recommended by the International Geological Congress was excellent, but the scheme proposed has proved impracticable owing to its application of old words to new things.

Buckman adopted a sounder policy when he introduced the term Hemera for the time equivalent to a zone.

Geologists have adopted some common words with meanings which render geological phraseology unintelligible or even ludicrous to the man who has not been warned that they require special interpretation. Thus the need in elementary teaching for emphasising the difference between mineral species and mineral aggregates has led to the frequent use of the term mineral as an abbreviation for mineral species. Some authors have been led by this practice to deny that mineral aggregates are minerals, and therefore assert that coal, most iron-ores, oil-shale, mineral oil, &c., are not minerals. According to that view the mineral industry has little concern with minerals; and the mineral resources of the British Isles, which are generally regarded as extensive, are reduced according to this nomenclature to practically nothing.

Another triumph of dauntless logic is the use of the word rock. It is no doubt convenient when speaking of the crust of the earth to have one term to cover all its materials; and rock is used in this way just as the dust in the atmosphere and the salts in the sea may be included with the air and the water. Hence has arisen the geological convention of calling any large constituent of the earth's crust a rock, quite regardless of the cohesion of its particles. G. H. Kinahan, for example, in his 'Handy Book of Rock Names' (1873) says, 'Thus loose sand, clay, peat, and even vegetable mould, geologically speaking, are rocks' (p. 1); and on page 131 he includes ice among rocks.

Now this use of the term ignores the very essence of the popular idea of a rock. The term appears to be derived from the same word as crag, and the essential quality of a rock is firmness. The parable of the man who built his house upon a rock would need to be retranslated, and Shakespeare's 'He's the rock, the oak not to be wind-shaken,'[10] loses its meaning if rock may be loose,

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[10] *Coriolanus*, V., 2, 117. Cf. also Zangwill—'Feeling solid-based upon eternal rock.'

drifting sand. The conventional use of the word *rock* in geology has been so widely adopted that objection to it may appear pedantic. Rosenbusch,[11] however, has defined Rocks as 'the geologically independent constituents, of more or less constant chemical and mineralogical composition, of which the firm (*feste*) crust of our earth is built.' Hence such definitions as that in my 'Structural Geography' (p. 21) of rocks as the firm coherent masses which form the main part of the lithosphere may shelter behind the high authority of Rosenbusch.

Reference to the paradox of calling clay and sand rocks reminds me that the word clay is now used in two very different senses in two sections of geology. In mineralogy the clays are a group of mineral species which are hydrous silicates of alumina. To the merchant, the farmer, and the economic geologist the essential quality of clay depends on texture and not on chemical composition. The word clay appears to be based on the same root as clog and cleave, while the Russian *glina* and the Greek γλία connect it with glue and glutin. The root of the word clearly refers to the adhesiveness which clay owes to its plasticity.

The essential property of clay is that it becomes plastic when wet. In England this property is chiefly found in material which, being formed from decomposed felspars, is a hydrous silicate of alumina; but other common materials have the same property, if ground to the requisite fineness. Quartz-flour is a common clay-forming material in many parts of the world, and much of the material called clay by the farmer is pure silica. Hence the definition of economic and agricultural geologists that clay is earthy material, which is plastic when wet because its particles are no more than 0·005 mm. in diameter, is a more commonsense definition than any based on chemical composition.[12]

If a name be wanted to distinguish clays which are silicate of alumina from clays of different composition, then a new name should be invented, instead of adopting a definition which refuses to accept as clay the slime of the quartz-miner, much of the Scottish boulder-clay, and any one of the nine brick-clays in the table of brick-clay analyses given by Ries.[13]

I have referred to a few instances to illustrate the frequent misappropriation of current terms by various branches of science, in the hope that the members of the Corresponding Societies will use their influence to discourage this practice. It should be remembered, however, that there are many cases in which it is a wise policy to transform a current popular term. It may be even justifiable, as in the case of minium and cinnabar, to use a word with the very opposite of its original meaning. A term may be adopted and redefined where, as in the cases of fish and worm, the popular meaning involves a wrong idea which it is advisable to correct, or overlooks a distinction which is practically important. Change and growth in nomenclature must be allowed. A dead language is very good for fixed ideas; but rigid adherence to original meanings is a bondage from which it is to be hoped scientific terminology may be always free. It is useless to suggest rules as to when popular terms may be revised; each case should be judged on its merits.

The casual adoption of current words with new meanings is often an attempt to secure specious simplicity at the price of subsequent confusion. Deissmann's recent book, 'Light from the Ancient East' (1910), calls attention to the misconceptions that have similarly arisen in theology, for he urges that words used in the New Testament are now understood in what the authors of that volume would decidedly call a non-natural sense. The idea that science is being driven into an intellectual wilderness owing to it's technical terminology is an idle bogey. Reference to the sporting or business columns of any daily paper will show that all specialised pursuits have their own special language. The language of golf is as technical as that of geology, and I venture to urge that science

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[11] H. Rosenbusch, *Elemente der Gesteinslehre*, Stuttgart, 1910, third edit., p. 1.

[12] Ries' definition, 'Clay is the term applied to those earthy materials occurring in Nature whose most prominent property is that of plasticity when wet' (H. Ries, *Clays: Their Occurrence, Properties, and Uses, with especial reference to those of the United States*, 1906, p. 1), is an example of those based on texture and not on composition.

[13] H. Ries, *ibid.*, p. 185.

will lose more by the misuse of current English than by the invention of new terms for new ideas and new materials. A rose by any other name may smell as sweet, but we cannot get sweet-smelling roses if we order them under the name of dandelions. In short, to put new meanings into standard English words appears to me as unjustifiable as to put home-brewed beer into Bass-labelled bottles.

The Vice-Chairman, in proposing a vote of thanks to Professor Gregory for his Address, said that in the New Forest the larva of the Fox moth was called by the labouring men the Palmer worm. Sir Charles Lyell throughout justified the use of the term 'rock' for all geological deposits by saying that it came from the Italian word 'rocca,' a term not confined to hard rocks.

The vote was seconded by Sir Edward Brabrook (Balham and District Antiquarian and N. H. Society), who, while thanking Professor Gregory for his treatment of a very fascinating subject, could not resist the gentle criticism that scientific men were partly to blame in the matter of their own misuse of scientific terms.

The vote was carried unanimously.

The Rev. T. R. R. Stebbing asked, as a matter of importance to the standing of the Conference, if it could not be arranged that the names of the delegates be printed in the daily programme with the title of the Chairman's Address and those of the papers for discussion.

It was pointed out that a list of the delegates already appeared in the list of members attending the meeting. As to the second query, it was notified that the Secretaries of the Association would be consulted. It was hoped that their answer would be favourable.

Mr. Alfred Pope (Dorset N. H. and Antiquarian Field Club) asked if the recommendation of the Conference passed at Leicester in 1907, that Corresponding Societies should obtain photographic surveys of places of natural beauty and buildings of historic or antiquarian interest in their several counties, had been followed, and in how many and in which counties such surveys had been commenced? So far as the society which he represented was concerned, he was glad to be able to report that a Photographic Section had been formed, and a Committee appointed, and that good work had been done in the direction suggested.

Mr. W. Whitaker (Essex Field Club), replying to Mr. Pope, said that a large amount of work had been done by such a survey in Surrey, and that considerable progress had been made by surveys on similar lines in Sussex and Kent. Several other counties where the enthusiasm and needful finances were forthcoming were also giving attention to the matter. It was one of great importance at a time when so much was disappearing with the growth of towns and under the guise of progress.

The Conference was then adjourned to the following week.

SECOND MEETING, *September 5.*

The Chairman, who again presided, opened the meeting and announced that the notice of proceedings of the Conference would in future be printed in the daily journal for the days on which it met.

Mr. F. Balfour Browne (Belfast Naturalists' Field Club) reported the results already reached in the interim report issued by the sub-committee of Sections D and K (p. 126). The subject of their labours is mentioned in the Report of the Corresponding Societies Committee. As a basis for further work the members of the sub-committee were all agreed as to the soundness of the Watsonian County and Vice-County System.

Mr. Harold Wager (British Mycological Society) opened a discussion on

The Study of Fungi by Local Natural History Societies.[14]

The following topics were briefly discussed: The importance of the study of Fungi. How Natural History Societies can best help in the work. Systematic

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[14] Printed in full in the *Naturalist,* October 1911.

studies. Large number of species of Fungi known: very few records in many districts. Further study and comparison of the Fungus Flora of different districts desirable. The work of the Mycological Committee of the Yorkshire Naturalists' Union. Many interesting biological problems connected with variation and distribution of the Fungi remaining for investigation. The succession of species in a given district throughout the seasons. Study of the Fungi of a single district. Edible and Poisonous Fungi. The life-history of the Fungi. Variations of form in the life-cycle of many species. Methods of reproduction. Absence of sexuality in many groups. Influence of external conditions. Colours of the Fungi. Recording observations. Drawings: photography. Colour-photography.

The Chairman heartily thanked Mr. Wager on behalf of the Conference for the exceedingly valuable and suggestive paper they had listened to. He hoped it would lead to a good discussion and increased interest in the subject.

Professor M. C. Potter (Newcastle-on-Tyne Literary and Philosophical Society) said that the subject was one in which there was much work still to do. He also drew attention to certain literature which might prove of value to members of the Conference.

Miss Lorrain Smith (British Museum) emphasised the importance of the problems suggested for study by Mr. Wager; many of them only to be studied by naturalists living in the country and able to watch the developments of the plants day by day. Accurate data were wanted as to the occurrence and different habitats of many of the species. Weather-changes are important as bearing on their development, and careful records were needed as to the species that succumb to unfavourable atmospheric conditions, and also as to those that are practically unaffected. Exact knowledge of species should be aimed at by all interested in the subject. A systematic study of fungi was strongly recommended.

Mrs. White (School Nature Study Union) remarked that the paper would be to her a message of encouragement to carry back to her Society. Three years ago the Union had started the study of fungi by means of forays, lectures, and demonstrations. The members had started in ignorance, had gradually acquired a knowledge of the kinds of fungi, and now were ready to attack problems such as Mr. Wager had suggested. She felt sure that they would be most grateful to Mr. Wager for having brought this subject forward.

Mr. W. N. Cheesman (Yorkshire Mycological Union) emphasised the importance of the study of mycology from an economic standpoint; probably one-half of the loss yearly of 200,000,000*l.* to vegetation by fungi could be averted by remedies. He suggested that natural history societies should encourage the study of mycology as an attractive section of their work and as giving employment to botanists, especially in the autumn, when flowering plants are hardly available. He would like to see a 'London Catalogue' giving localities and frequency of species. Finally, he would welcome any endeavour to focus the scattered work of mycologists throughout the country.

Miss H. C. I. Fraser (London) agreed as to the very valuable work which lay in the power of local N.H. societies. She emphasised the need of the study of discomycetous forms, and pointed out that an accurate knowledge of their occurrence in the field was an important preliminary to the investigation of their minute structure. She suggested that the Central Committee referred to might usefully be formed in relation with the British Mycological Society.

Mr. F. T. Brooks (Cambridge Botany School) spoke of the great help frequently given to laboratory-workers by members of local natural history societies who devoted time to the study of fungi in the field. He emphasised the importance of paying special attention to the distribution and frequency of fungus-pests in any organised survey of the fungus-flora of this country. He also appealed for some instruction in the use of fungi as food, instancing the fact that on the Continent many more kinds are commonly eaten than in Britain.

Sir Daniel Morris (Bournemouth Natural Science Society) reiterated the fact that natural history societies could easily take up the study of fungoid plant-pests in their district. As an instance of work to be done on the South Coast, he called the attention of botanists to a fungus on the leaves of *Euonymus.*

This growth, which had the effect of whitewash, appeared first about ten years ago at Brighton, and seemed to be rapidly spreading. It had been described by Mr. Massee, of Kew, but no attack had yet been recorded there. Gardeners on the South Coast at present did not seem to understand it. By clipping the plant to make it look more presentable they only weakened it and made it look more bare.

The Rev. T. R. R. Stebbing asked whether those medical men were to be trusted who affirmed that edible fungi, however agreeable they might be to the palate, had practically no value as nutriment. On the other hand, he believed that the enormous pecuniary damage caused by some insidious members of the class was compensated by the efficient help which other members of it gave to higher vegetation.

Miss Lorrain Smith explained that some parts of the vegetable kingdom did in fact find the co-operation of fungi essential and invaluable.

Mr. W. P. D. Stebbing, with reference to the value of fungi to the human race, could not help alluding to their far greater use on the Continent than in the British Isles. They form a striking feature in the markets down the Loire, at Toulouse, and in Rome, where in the autumn the large brown and yellow *Boletus* seems to be an especial favourite. He asked if any satisfactory method of preserving them was in use? As a matter of curiosity, he would like to know if there was anything in the common saying that a wet summer drowned the mycelium of the *Agaricus campestris*. Sir Daniel Morris's remarks led him to ask if the white fungus attacking the leaves of young oak-shoots in summer was similar to the one now affecting the *Euonymus*?

The Chairman, in closing the discussion and before calling on Mr. Wager to reply, drew the attention of the Conference to the exhibition of drawings, dissections, and photographs of fungi hung round the walls. For them the Conference was very deeply indebted to Mr. A. Clarke, of Huddersfield (stereoscopic photographs of fungi); to Mr. Clarke and Mr. A. E. Peck, of the same town (photographs of British fungi); to Mr. C. Crossland, of Halifax (water-colour drawings with magnified dissections of British micro- and other fungi); and to Mrs. W. P. D. Stebbing and Mrs. T. R. R. Stebbing for water-colour drawings of fungi, mainly from the counties of Surrey and Kent.

Mr. Wager thought that Sir Daniel Morris had indicated very clearly one of the problems of economic importance in the solution of which the observations of members of Local Societies might be of very considerable value. It was clearly desirable that natural history societies should have very definite problems placed before them, and he was glad to learn from the remarks made by one of the speakers that some such guidance would be welcomed.

Co-ordination of the Work of Local Scientific Societies.

Sir Daniel Morris opened a discussion on the above subject, which he thought was of supreme importance if the best use was to be made of the energy now often lost in such societies, or when there were rival societies in the same town. He considered that co-ordination would prevent stagnation and direct surplus energy through discussions into more profitable channels.

Dr. Tempest Anderson (Yorkshire Philosophical Society) pointed out that union is strength; for instance, the British Association with its numerous Sections wielded an influence for good far greater than would be the case if the different Sections were separate organisations. The same was the case with the new Royal Society of Medicine, formed by an amalgamation of the various medical societies of London.

Mr. Beeby Thompson (Northants N. H. Society and Field Club) remarked that the society which he represented was conducted on the lines suggested by Sir Daniel Morris. There were various sections, each with its own president and secretary, and they were given independent management of their own affairs. Two of the sections admit sectional members for a much smaller subscription than that to the parent society, but since the proceedings of these sections and their more important papers are published in the Quarterly Journal of the Society, they act as feeders to it. That is to say, the sectional members

often find it desirable to have the Journal and to enjoy the other privileges which full membership provides.

Mr. W. Whitaker said that the Croydon N. H. and Scientific Society, of which he was president, had a number of separate sections, each with its committee, which met on their own days. The inevitable drawback was that each section rather depended on the work it could do, according as the membership was strong or the reverse.

Mr. William Parkin (Sheffield Naturalists' Club) mentioned that his club also was divided into various sections, each of which met monthly for comparison of work, while the club annually published 'Transactions' of what had been done. He tendered thanks to the Conference for the admission of the club to the list of Corresponding Societies.

Mr. Mark L. Sykes (Manchester Microscopical Society) supported the opener's words. Every branch of science, especially biological, being so dependent upon the other, his society had extended its operations, and is practically a biological society, with sections, giving the members practical demonstrations on zoological, botanical, pathological, and allied subjects, enabling it to issue valuable 'Annual Transactions.' By the amalgamation of small societies into one composite whole, especially in the smaller towns, more practical and useful work would be carried out than by the small divided efforts of minor societies.

Mr. W. M. Webb and the Chairman also joined in the discussion, and Sir Daniel Morris replied.

Mr. Wilfred Mark Webb (Selborne Society) thus introduced a discussion on the following subject :—

The Protection of Plants.

Those of you who happen to be secretaries of societies well know that the usual reward for putting forward what is generally considered to be a good idea is to be asked to carry it out.

Now, when I fulfilled the request of our Committee made to all Corresponding Societies, and modestly suggested a matter that might with advantage be brought before this Conference, I naturally did so in the pious hope that it would be among those chosen for consideration.

I am therefore much pleased that a discussion on plant-protection, which was the one that I advocated, has been arranged, but I have been further rewarded beyond my deserts, as an ordinary member of this Conference, by being asked to introduce the subject.

It is needless to bring forward any special arguments to prove that many plants are being exterminated. This is shown by the continual complaints which appear in the newspapers, as well as by the fact that a Committee of the British Association between the years 1887 and 1892 issued five reports on the disappearance of British plants, while it should further be mentioned that Mr. A. R. Horwood dealt with the extinction of Cryptogams at the Leicester Meeting of the British Association, and last year read a most detailed and comprehensive paper on the subject before the South-Eastern Union of Scientific Societies.

The necessity for protection is obvious, and the matters which most concern us are, what has been done and what can be done to mitigate the effects of those causes of extermination which we cannot remove, or which are difficult to counteract, as well as what means can be devised to get rid of those which are easily preventable.

Turning to Mr. Horwood's paper, we find that he gives no fewer than forty causes for the extinction of the plants with which he deals, and it will be convenient to consider his list, which is ready to our hands. Of the twelve main causes which he enumerates, four come under the heading of climate, which we may leave on one side. The others are all effects of civilisation and the accompanying extension of industries. The first three of these are agricultural, and include the reclamation of land by drainage or otherwise, the cultivation and planting of new areas, and the deforestation of others.

Considering these, which in the majority of cases are necessary evils from our point of view, the solution of the difficulty seems to lie in the formation

of reservations of considerable area, so far as possible, left in their natural state, where plants generally may flourish; and the special protection of small enclosures in which rare or local species may grow undisturbed, and, at the same time, some of the showy and striking of our commoner plants find a sanctuary until such time as legislation and public opinion may permit of their remaining undisturbed in unguarded places.

It has always seemed to me that a number of landowners would only be too glad to help in the matter if a movement in its favour became general, and there already exists a large number of open spaces which have never been Common Lands, on part of which it would be easily possible to make the small enclosures suggested. I may here add that some little time ago I had a conversation with Mr. Nigel Bond, when he was Secretary of the National Trust, and more recently with Sir Robert Hunter, Chairman of the Executive Committee, and I am authorised to say that the National Trust would be willing to consider the suggestion in connection with many of their properties.

It is, however, likely that the authorities responsible for open spaces would not have funds at their disposal which they could spend on fencing and keepers, but special subscriptions might be raised generally or locally, and it might be found possible to grow such impenetrable hedges round the chosen spots that in course of time little attention would be needed.

The next causes come under the heading 'Industrial.' Smoke and injurious gases, for general as well as special reasons, are being dealt with by smoke-abatement societies, and it might be possible to strengthen their hands. The putting up of buildings may be taken for all practical purposes as meaning the entire destruction of the local flora on the spots concerned, whereas agricultural operations only damage it, and this reminds one of the fact that with towns come municipal bodies, which do not always recognise that it may not be necessary nor advisable for the whole of every open space to be converted into a park or recreation-ground, and made into a flat field or a series of gravel-paths and flower-beds. It is too often the case that as soon as a district or other council obtains possession of a piece of land they begin to fill in all the ponds, plant little patches of trees, and put up a bandstand in a position where it cannot but be an eyesore.

Mr. Horwood's next heading is that of Sport. He urges that the formation of golf-links, cricket-pitches, and race-courses has often destroyed the habitat of some rare flowering plant, moss, or lichen. At the same time, it must be remembered that if it were not for sports many of the spaces which remain open would have been covered with houses before now. In cases where open spaces are about to be used for purposes of games, it should surely be possible for properly organised scientific opinion to make itself felt, and if it is known that rare plants are restricted to a small area, this knowledge should have sufficient weight to prevent any cricket-pitch or putting-green being made on that habitat. It seems strange that the educated people in a small place should have less to say in the matter of its amenities than those who are presumably less cultured.

The next cause of extermination is the plucking of flowers and the digging up of plants by hawkers who sell them in the streets, and by other gatherers who dispose of the roots to dealers or to private persons.

This would not go on if there were not a demand for wild plants, and if the taste of the public had not improved so far as to prefer the natural blossoms of the wayside to the cultivated and often monstrous flowers of the garden, but if things go on as they are, there will soon be no wild flowers to admire. There is no doubt but that legislation is the only thing which will lessen the evil, though it may not cure it altogether. Several county councils have already passed by-laws on the subject.

At the request of certain parish councils the Kent County Council has been taking steps to pass a similar by-law, but the Home Secretary has delayed the matter by asking for further information.

These by-laws refer only to roads, commons, and other public places, as the councils have no jurisdiction over private property. At present the owners have no power to prevent wild plants from being removed from their land, and it is certain that most of the ferns and many other plants which are carried

away must be taken from private property. Something may be done to hinder the traffic if those in sympathy with plant-protection refuse to buy any wild flowers in the streets or to purchase them from those who advertise them. As time goes on, no doubt the nurserymen will find that it will pay them to cultivate wild flowers, at any rate in order to dispose of the plants.

The last of the main causes is collecting. There is the indiscriminate collection by the lover of wild flowers, who likes to get temporary pleasure at the expense of those who come after; the children who pick showy flowers carelessly, and thus often decimate some struggling species. There is also the scientific collector who is greedy, or cannot resist the temptation of securing specimens when it would be advisable to take none at all. Of course, it is very often difficult in this respect not to have one rule for yourself and another for other people, and I have heard a statement made that a botanist who has been a strong advocate of plant-protection helped himself in one case so lavishly to a rare plant, that it was never seen again. Surely it should be possible at this stage to discredit people who destroy rarities, by introducing some rule into the societies to which they belong, but, unfortunately, there is no general biological council that will determine how naturalists shall behave and keep them in order, as is done by the associations which look after the doctors and solicitors.

Of the twenty-eight minor causes set out by Mr. Horwood, most may be of importance in special localities and under particular circumstances. One or two are of general interest, such as the burning of furze and heather, which is often done by keepers to prevent pheasants from straying on to common land, and the clearing out of ditches, or cutting down of hedges, which is often carried out to an unnecessary extent. These are among the causes that, with trouble, might be lessened as time goes on, but if much is to be done in the way of plant-protection some organisation must take the matter in hand. I may say at once, that one already exists which may be able to do so efficiently. As the result of Mr. Horwood's paper to the South-Eastern Union, the Council of that body approached the Selborne Society, which by the issue of leaflets and in other ways has for the last quarter of a century been quietly urging the public to protect animals and plants as well as places of natural beauty and historic interest. The results of its work may be measured in some directions by what other societies have done which have followed its example, except that they have directed the whole of their energies to one object.

Plant-protection, except by Local Societies, has been left to the Selborne Society, and quite recently a special section has been appointed to deal with the matter in a militant way, but it will not be able to do much unless it gets the cordial co-operation of naturalists all over the country, of the Press, of the schoolmasters, and of the clergy and landowners, and I take this opportunity of reading a few paragraphs drawn up in the way of a report as to the means which should be taken to the end in view:—

'We are quite satisfied as to the need for plant protection, and we have the support of a number of eminent naturalists. The first step to be taken is to influence public opinion on the subject of the wholesale destruction of wild plants with a view—

'(1) To persuading other county and borough councils to follow the lead of those of Devon, Essex, and Surrey, who have applied for local orders for preserving wild flowers, though apparently they only refer to road-sides and public places under the jurisdiction of the Council.

'(2) To obtaining further powers for the county councils with reference to the grubbing up of plants on private grounds.

'(3) To introducing a Bill on the subject into Parliament on the lines of the one drawn up by Professor Boulger; Lord Avebury being of opinion that the time is ripe for such a measure.

'It is suggested that opinion should be influenced by appealing to the Press, by correspondence with the natural history societies and the clergy in country towns and villages throughout the country, and by the distribution of literature as well as by the giving of lectures and the publication of reports detailing the extent of extinction in each county.

'The second part of the Committee's endeavours would be to secure the preservation of rare plants (which might be scheduled in the Bill proposed) by securing reservations for them. In a similar way, reservations should also be obtained for special types of vegetation (plant associations).

'Still another piece of work which the Section should attempt is the collection of information on which future endeavours could be based.

'Your Council made a grant to the Section and empowered it to appoint a General Committee and to accept contributions of money to be spent on its own particular work.'

My own impression is that although individuals may get ideas from discussions, general action does not, as a general rule, follow, and I therefore appeal to all present to do everything in their power now and afterwards to offer all the help possible to bring about a better state of affairs, which we all in our hearts desire.

Mr. W. P. D. Stebbing agreed that many of the destructive agencies brought before the Conference by Mr. Webb were becoming of supreme importance to those interested in the British flora. One could not help noticing the great waste of plant-life purely for amusement going on in the neighbourhood of large towns, and the way at present common but bright-coloured flowers were torn up by trippers. Many must have seen the growing loss by the country-side of marketable plants for sale by hawkers. There was a continuous robbery from the Surrey woodlands of honeysuckle; and in recent years in the same county wholesale robbery of holly by men with sacks and carts had, unhappily, become common just before Christmas. A tree covered with berries was noted in daylight. At dark the thieves with their apparatus descended, and if the coast was clear, stripped the tree bare. Golf clubs certainly were responsible for much destruction on public heaths and other spaces. The speaker instanced the present state of Walton Heath in Surrey, and the formerly interesting gravel-pitted tract of country now occupied by the West Middlesex Golf Club at Hanwell. In Scotland, in the praiseworthy efforts to reduce grouse-disease, probably much interesting plant-life was destroyed in the recommended systematic burning of the moors. Even the preservation of game was liable to limit the natural growth of interesting plants in woodlands. Landowners did not like to put restrictions on their tenants (shooting or otherwise) after the land had been let. He had in his mind at the moment a colony of lily of the valley in a wood let to a shooting tenant, which the gamekeepers and their friends never allowed to flower in peace. Much might be done by corporations which became possessed of tracts of wild land in the way of sanctuaries, when it was known that certain interesting plants which everyone wanted to pick grew about it. Even in towns, although sanctuaries cannot be reserved, colonies can be made. One of the most delightful wild features in our London parks at the present time is the five-year-old natural-looking pond in the Outer Circle of the Regent's Park, with its glorious collection of free-growing water and bankside plants.

Mr. W. Whitaker said the Borough of Croydon had made use of its powers in the management of its open spaces. · Determining to put a stop to the wholesale removal of heather from the Addington Hills, it had instituted a series of prosecutions, and had succeeded in having fines inflicted on some dozens of those who for their own selfish ends were gradually stripping the area of one of its great glories.

Miss Crosfield (Holmesdale N. H. Club) gave some information about Colley Hill, many acres of which were now preserved as an open space by the Borough of Reigate, and of which it was hoped that a good many more would be obtained through the efforts now being made by the National Trust. She said that colonies of the bee-orchis still existed near by.

The Vice-Chairman, on behalf of the Conference, thanked Mr. Webb for his paper.

THE CORRESPONDING SOCIETIES OF THE BRITISH ASSOCIATION FOR 1911-1912.

Affiliated Societies.

Full Title and Date of Foundation	Headquarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Andersonian Naturalists' Society, 1885	Technical College, Glasgow. R. Barnett Johnstone and George Luuam	298	None	2s. 6d.	Annals, occasionally.
Ashmolean Natural History Society of Oxfordshire, 1828	Miss A. L. Stone, 2 St. Margaret's Road, Oxford	300	None	5s.	Report, annually.
Belfast Natural History and Philosophical Society, 1821	Museum, College Square. R. M. Young, M.R.I.A.	250	None	1l. 1s.	Report and Proceedings, annually.
Belfast Naturalists' Field Club, 1863	Museum, College Square. A. W. Stelfox	386	5s.	5s.	Report and Proceedings, annually.
Berwickshire Naturalists' Club, 1831	Rev. J. J. M. L. Aiken, B.D., Manse of Ayton, Berwickshire	400	10s.	8s. 6d.	History of the Berwickshire Naturalists' Club, annually.
Birmingham and Midland Institute Scientific Society, 1859	Alfred Cresswell, Birmingham and Midland Institute, Paradise Street, Birmingham	137	None	10s. 6d. and 5s.	Records of Meteorological Observations, annually.
Birmingham Natural History and Philosophical Society, 1858	Avebury House, Newhall Street, Birmingham. W. H. Foxall and Herbert Stone, F.L.S.	197	None	1l. 1s.	Proceedings, occasionally.
Bournemouth Natural Science Society, 1903	H. Le Jeune, St. Ives, Ashley Road, Upper Parkstone, Bournemouth	344	None	10s. and 7s. 6d.	Report and Proceedings, annually.
Brighton and Hove Natural History and Philosophical Society, 1854	J. Colbatch Clark, 9 Marlborough Place, Brighton	150	None	10s.	Report, annually.
Bristol Naturalists' Society, 1862	J. H. Priestley, B.Sc., The University, Bristol	135	5s.	10s. and 5s.	Proceedings, annually.
British Mycological Society, 1896	Carleton Rea, 34 Foregate Street, Worcester	91	None	10s.	Transactions, annually.
Buchan Club, 1887	J. F. Tocher, B.Sc., 5 Chapel Street, Peterhead	180	5s.	5s.	Transactions, annually.
Burton-on-Trent Natural History and Archæological Society, 1876	G. S. Hollister, F.G.S., Iverleigh, Scalpcliffe Road, Burton-on-Trent	250	None	5s.	Report, annually; Transactions, occasionally.
Canada, Royal Astronomical Society of, 1884	Canadian Institute Building, Toronto. J. R. Collins	450	None	2 dollars	Journal, bi-monthly.
Caradoc and Severn Valley Field Club, 1893	H. E. Forrest, 37 Castle Street, Shrewsbury	205	5s.	5s.	Transactions and Record of Bare Facts, annually.
Cardiff Naturalists' Society, 1867	Dr. Owen L. Rhys, 22 St. Andrew's Crescent, Cardiff	500	None	12s. 6d.	Transactions, annually.
Chester Society of Natural Science, Literature, and Art, 1871	Grosvenor Museum, Chester. F. Simpson	1,020	None	5s. and 2s. 6d.	Report, annually; Proceedings, occasionally
Cornwall, Royal Geological Society of, 1814	The Museum, Public Buildings, Penzance. John B. Cornish	84	None	1l. 1s.	Transactions, annually.
Cornwall, Royal Institution of, 1818	George Penrose, F.L.S., County Museum, Truro	195	None	1l. 1s.	Journal, annually.
Cornwall, Royal Polytechnic Society, 1833	E. W. Newton, 4 Cross Street, Camborne Cornwall	400	None	10s. upwards	Report, annually.
Cotteswold Naturalists' Field Club, 1846	L. Richardson, 10 Oxford Parade, Cheltenham.	110	1l.	15s.	Proceedings, annually.
Croydon Natural History and Scientific Society, 1870	Public Hall, Croydon. G. W. Moore	127	None	10s., 5s., and 2s. 6d.	Proceedings and Transactions, annually.
Dorset Natural History and Antiquarian Field Club, 1875	Rev. Herbert Pentin, M.A., M.R.A.S., Milton Abbey Vicarage, Dorset	400	10s.	10s.	Proceedings, annually.

Dublin Naturalists' Field Club, 1885	Alfred H. Toppin, Merrion Lodge, Merrion, Co. Dublin.	125	5s.	5s.	'Irish Naturalist,' monthly; Report, annually.
Dumfriesshire and Galloway Natural History and Antiquarian Society, 1862	G. W. Shirley, Ewart Public Library, Dumfries	279	None	5s.	Transactions and Proceedings, annually
East Kent Scientific and Natural History Society, 1857	A. Lander, 17 High Street, Canterbury	78	None	10s. and 5s.	Transactions, annually.
Eastbourne Natural History, Scientific, and Literary Society, 1867	Henry Sparks, Villa Ruhe, 5 St. Leonard's Road, Eastbourne	77	2s. 6d.	7s. 6d.	Transactions, biennially.
Edinburgh Field Naturalists' and Microscopical Society, 1869	Allan A. Pinkerton, 19 Shandwick Place, Edinburgh	202	5s.	5s.	Transactions, annually.
Edinburgh Geological Society, 1834	India Buildings, Edinburgh. David Gloag	226	10s. 6d.	12s. 6d.	Transactions, annually.
Elgin and Morayshire Literary and Scientific Association, 1836	Norris Mackay, W.S., 54 High Street, Elgin	88	None	5s. and 2s. 6d.	Transactions, occasionally.
Essex Field Club, 1880	Essex Museum of Natural History, Romford Road, Stratford. W. Cole and B. G. Cole	300	None	15s.	'Essex Naturalist,' quarterly; 'Year-book,' annually; 'Special Memoirs,' &c., occasionally.
Glasgow, Geological Society of, 1858	Peter Macnair, F.R.S.E., 207 Bath Street, Glasgow	300	None	10s.	Transactions and Proceedings, annually.
Glasgow, Natural History Society of, 1851	Alex. Ross, 409 Great Western Road, Glasgow	260	None	7s. 6d.	'Glasgow Naturalist,' quarterly.
Glasgow, Royal Philosophical Society of, 1802	Prof. Peter Bennett, 207 Bath Street, Glasgow	1,000	1l. 1s.	1l. 1s.	Proceedings, annually.
Hampshire Field Club and Archæological Society, 1885	W. Dale, F.S.A., F.G.S., The Lawn, Archer's Road, Southampton	250	5s.	10s. 6d.	Proceedings, annually.
Hertfordshire Natural History Society and Field Club, 1875	Charles Oldham, Kelvin, Berkhamsted, and E. J. Salisbury, Limbrick Hall, Harpenden	144	None	10s.	Transactions, annually.
Holmesdale Natural History Club, 1857	Miss M. C. Crosfield, Undercroft, Reigate	81	None	10s. and 5s.	Proceedings, occasionally.
Hull Geological Society, 1887	J. W. Stather, F.G.S., Newland Park, Hull	70	None	5s.	Transactions, occasionally.
Hull Scientific and Field Naturalists' Club, 1886	T. Stainforth, The Museum, Hull	135	None	5s.	Transactions, annually.
Institution of Mining Engineers, 1889	Percy Strzelecki, 39 Victoria Street, London, S.W.	3,350	None	None	Transactions, monthly.
Ireland, Statistical and Social Inquiry Society of, 1847	W. Lawson, Dr. N. M. Falkiner, and Herbert Wood, 6 Eustace Street, Dublin	80	None	1l.	Journal, annually.
Leeds Geological Association, 1873	E. Hawkesworth, Crossgates, Leeds	116	None	5s.	Transactions, occasionally.
Leicester Literary and Philosophical Society, 1835	Corporation Museum. C. H. Spencer, 50 Knighton Drive, Leicester	289 Membs. & Associates	None	Members 1l. 1s.; Associates 10s. 6d.	Transactions, annually.
Lincolnshire Naturalists' Union, 1893	Arthur Smith, F.L.S., City and County Museum, Lincoln	112	None	5s.	Transactions, annually.
Liverpool Biological Society, 1886	J. A. Clubb, D.Sc., Free Public Museum, Liverpool	100	10s. 6d. and 2s. 6d.	1l. 1s. and 10s. 6d.	Proceedings and Transactions, annually.
Liverpool Botanical Society, 1906	A. A. Dallman, F.C.S., 111 Penny Lane, Wavertree, Liverpool	130	None	5s.	Proceedings, annually; Transactions, occasionally.
Liverpool Engineering Society, 1875	T. R. Wilton, M.A., 1 Crosshall Street, Liverpool	541	None	1l. 1s. and 10s. 6d.	Transactions and Report, annually.
Liverpool Geographical Society, 1891	Capt. E. C. Dubois Phillips, R.N., 14 Hargreave's Buildings, Liverpool	650	None	Members 1l. 1s.; Associates 10s. 6d.	Transactions and Report, annually.
Liverpool Geological Society, 1858	Royal Institution. W. A. Whitehead, B.Sc.	105	None	10s. 6d.	Proceedings, annually.
London: Quekett Microscopical Club, 1865	W. B. Stokes, 4 Winn Road, Lee, S.E.	480	None	10s.	Journal, half-yearly.
London: Selborne Society, 1885	42 Bloomsbury Square, W.C. W. M. Webb, F.L.S.	3,000	None	5s.	'Selborne Magazine,' monthly.
Man, Isle of, Natural History and Antiquarian Society, 1879	P. M. C. Kermode, Claghbane, Ramsey, Isle of Man	224	2s. 6d.	7s. 6d. and 5s.	Proceedings, twice a year; Transactions, occasionally.

Affiliated Societies—continued.

Full Title and Date of Foundation	Headquarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Manchester Geographical Society, 1884	J. Howard Reed, 16 St. Mary's Parsonage, Manchester	700	None	Members 1*l*. 1*s*.; Associates 10*s*. 6*d*.	Journal, quarterly.
Manchester Geological and Mining Society, 1838	5 John Dalton Street, Manchester. Sydney A. Smith	300	None	2*l*. 2*s*., 1*l*. 5*s*., and 1*l*.	Transactions of Inst. of Mining Engineers, monthly.
Manchester Microscopical Society, 1880	Frederick Dishley, 14 Westwood Street, Moss Side, Manchester	184	5*s*.	6*s*.	Transactions and Report, annually.
Manchester Statistical Society, 1833	Herbert Heape and F. Vernon Hansford, 3 York Street, Manchester	167	10*s*. 6*d*.	10*s*. 6*d*.	Transactions, annually.
Marlborough College Natural History Society, 1864	E. Meyrick, F.R.S., Marlborough College	300	1*s*. 6*d*.	3*s*. and 5*s*.	Report, annually.
Midland Counties Institution of Engineers, 1871	G. Alfred Lewis, M.A., Albert Street, Derby	395 Membs., Associates, & Students	1*l*. 1*s*. None	Members 42*s*.; Associates and Students 20*s*.	Transactions of Institution of Mining Engineers, monthly.
Midland Institute of Mining, Civil, and Mechanical Engineers, 1869	L. T. O'Shea, The University, Sheffield	306	None	1*l*. 10*s*.	Transactions of Inst. of Mining Engineers, monthly.
Norfolk and Norwich Naturalists' Society, 1869	W. A. Nicholson, 81 Surrey Street, Norwich	290	None	6*s*.	Transactions, annually.
North of England Institute of Mining and Mechanical Engineers, 1852	Neville Hall, Newcastle-upon-Tyne. Laurence Austin	1,362	None	25*s*. and 42*s*.	Transactions of Inst. of Mining Engineers, monthly.
North Staffordshire Field Club, 1865	W. Wells Bladen, Stone, Staffs	650	5*s*.	5*s*.	Report and Transactions, annually.
Northamptonshire Natural History Society and Field Club, 1876	H. N. Dixon, M.A., 17 St. Matthew's Parade, Northampton	210	None	10*s*.	Journal, quarterly.
Northumberland, Durham, and Newcastle-upon-Tyne, Natural History Society of, 1829	Hancock Museum, Newcastle-on-Tyne. C. E. Robson and J. A. Richardson	420	None	21*s*.	Transactions, annually.
Nottingham Naturalists' Society, 1852	Prof. J. W. Carr, M.A., University College, Nottingham	182	2*s*. 6*d*.	5*s*.	Report and Transactions, annually.
Paisley Philosophical Institution, 1808	J. Gardner, 3 County Place, Paisley	542	5*s*.	7*s*. 6*d*.	Report and Meteorological Observations, annually.
Perthshire Society of Natural Science, 1867	Tay Street, Perth. S. T. Ellison	363	2*s*. 6*d*.	5*s*. 6*d*.	Transactions and Proceedings, annually.
Rochdale Literary and Scientific Society, 1878	J. Reginald Ashworth, D.Sc., 105 Freehold Street, Rochdale	241	None	6*s*.	Transactions, biennially.
Rochester Naturalists' Club, 1878	John Hepworth, Linden House, Rochester	154	None	5*s*.	'Rochester Naturalist,' quarterly.
Sheffield Naturalists' Club, 1870	C. Bradshaw, Public Museum, and C. J. Hardy, 31 Hampton Road, Sheffield	100	None	10*s*. and 5*s*.	Report, annually: Proceedings, occasionally.
Somersetshire Archæological and Natural History Society, 1849	The Castle, Taunton. Rev. F. W. Weaver, Rev. E. H. B. Harbin, and O. Tite	852	10*s*. 6*d*.	10*s*. 6*d*.	Proceedings, annually.
South Africa, Royal Society of, 1906	G. M. Clark, South African Museum, Cape Town	207	None	2*l*.	Transactions, occasionally.
South-Eastern Union of Scientific Societies, 1896	W. Martin, LL.D., 2 Garden Court, Temple, E.C.	59 Societies	None	Minimum 5*s*.	'South-Eastern Naturalist,' annually.
Southport Literary and Philosophical Society	A. H. Garstang, 120 Roe Lane, Southport	130	None	7*s*. 6*d*.	Proceedings, occasionally.

South Staffordshire and Warwickshire Institute of Mining Engineers, 1867	G. D. Smith, 3 Newhall Street, Birmingham	150	1*l.* 1*s.* and 10*s.* 6*d.*	42*s.* and 21*s.*	Transactions of Institution of Mining Engineers, monthly.
Torquay Natural History Society, 1844	Major E. V. Elwes, The Museum, Torquay	189	10*s.* 6*d.*	1*l.* 1*s.*	Journal, annually.
Tyneside Geographical Society, 1887	Geographical Institute, St. Mary's Place, Newcastle-on-Tyne. Herbert Shaw, B.A., F.R.G.S.	800	None	21*s.* and 10*s.*	Journal, annually.
Vale of Derwent Naturalists' Field Club, 1887	J. R. Patterson, Mossgiel, Rowlands Gill, R.S.O.	160	None	2*s.* 6*d.*	Transactions, occasionally.
Warwickshire Naturalists' and Archæologists' Field Club, 1854	Museum, Warwick. O. West, Cross Cheaping, Coventry	70	2*s.* 6*d.*	5*s.*	Proceedings, annually.
Woolhope Naturalists' Field Club, 1851	Woolhope Club Room, Free Library, Hereford. T. Hutchinson	216	10*s.*	10*s.*	Transactions, occasionally.
Worcestershire Naturalists' Club, 1847	Education Offices, Worcester. F. T. Spackman, F.G.S.	150	10*s.*	5*s.*	Transactions, annually.
Yorkshire Geological Society, 1837	Cosmo Johns, Burngrove, Pitsmoor Road, Sheffield	200	None	13*s*	Proceedings, annually.
Yorkshire Naturalists' Union, 1861	The Museum, Hull. T. Sheppard, F.G.S.	419 and 3,449 Associates	None	10*s.* 6*d.*	Transactions, annually; 'The Naturalist,' monthly.
Yorkshire Philosophical Society, 1822	Museum, York. Dr. Tempest Anderson and C. E. Elmhirst	500	None	2*l.*	Report, annually.

Associated Societies.

Balham and District Antiquarian and Natural History Society, 1897	A. L. Barron, Clophill, Wallington, Surrey	73	None	5*s.*	Papers, occasionally.
Barrow Naturalists' Field Club and Literary and Scientific Association, 1876	W. L. Page, 5 Cavendish Street, Barrow	255	None	5*s.* and 2*s.* 6*d.*	Report and Proceedings, annually.
Battersea Field Club, 1894	Public Library, Lavender Hill, Battersea, S.W. Miss L. B. Morris	60	2*s.* 6*d.*	3*s.* 6*d.*	—
Bradford Natural History and Microscopical Society, 1875	Fred. Jowett, 2 Vincent Street, Bradford	85	1*s.*	4*s.*	Report, annually.
Bradford Scientific Association, 1875	A. Smith, Springfield, Guiseley, Yorks.	185	None	5*s.* and 2*s.* 6*d.*	Bradford Scientific Journal, quarterly.
Catford and District Natural History Society, 1897	W. H. Griffin, 40 Blythe Vale, Catford, S.E.	86	None	5*s.*	—
Dover Sciences Society, 1879	C. E. Dall, B.Sc., 26 Beaconsfield Avenue, Dover	49	None	5*s.*	Report, annually.
Dunfermline Naturalists' Society, 1902	Robert Somerville, B.Sc., 38 Cameron Street, Dunfermline	165	None	3*s.*	—
Ealing Scientific and Microscopical Society, 1877	F. McNeil Rushforth, Coley Lodge, 21 Florence Road, Ealing, W.	187	None	10*s.* and 2*s.* 6*d.*	Report and Transactions, annually.
Grimsby and District Antiquarian and Naturalists' Society, 1896	The Museum, Grimsby. A. Bullock	85	None	4*s.*	—
Halifax Scientific Society, 1874	F. Barker, 11 Hall Street, Halifax	137	None	2*s.* 6*d.*	—
Hampstead Scientific Society, 1899	C. O. Bartrum, B.Sc., and R. W. Wylie, M.A., 32 Willoughby Road, Hampstead, N.W.	329	None	Minimum 5*s.*	Report and Proceedings, annually.
Hastings and St. Leonards Natural History Society, 1893	Corporation Museum, Brassey Institute, Hastings. W. Ruskin Butterfield	460	1*s.*	2*s.* 6*d.*	'Hastings and East Sussex Naturalist,' occasionally

Associated Societies—continued.

Full Title and Date of Foundation	Headquarters or Name and Address of Secretary	No. of Members	Entrance Fee	Annual Subscription	Title and Frequency of Issue of Publications
Hawick Archæological Society, 1856	J. J. Vernon, 81 High Street, Hawick	275	None	2*s.* 6*d.*	Transactions, annually.
Hull Society of Natural Science 1904	A. J. Moore, 9 Brook Street, Hull	70	None	4*s.*	Proceedings, occasionally.
Inverness Scientific Society and Field Club, 1875	Thomas Wallace, Eller-lie, Inverness	195	None	5*s.*	Transactions, occasionally.
Ipswich and District Field Club, 1903	C. R. Bacon, 107 Rosehill Road Ipswich	142	None	2*s* 6*d.*	Journal, annually.
Lancashire and Cheshire Entomological Society, 1877	Royal Institution, Liverpool. H. R. Sweeting, M.A.	140	None	5*s.*	Report and Proceedings annually.
Leeds Naturalists' Club and Scientific Association, 1868	C. H. B. Turner, 37 Sholebroke Place, Leeds	100	None	6*s.*	Proceedings, occasionally.
Lewisham Antiquarian Society, 1885	J. W. Brookes, Pembroke Lodge, Slaithwaite Road, Lewisham, S.E.	96	None	5*s.*	Transactions, occasionally.
Liverpool Microscopical Society, 1868	Royal Institution, Liverpool. R. Croston	55	None	10*s.* 6*d.*	Report, annually.
Liverpool Science Students' Association, 1881	Royal Institution, Liverpool. H. W. Greenwood	48	2*s.* 6*d.*	5*s.*	—
Llandudno and District Field Club, 1906	L. S. Underwood, Brinkburn, Llandudno	165	None	5*s.*	Proceedings, annually.
London: City of London Entomological and Natural History Society, 1858	The London Institution, Finsbury Circus, E.C. T. H. L. Grosvenor.	79	2*s.* 6*d.*	7*s.* 6*d.*	Transactions, annually.
London: North London Natural History Society, 1892	T. R. Brooke, 12 Warren Road, Chingford	160	2*s.* 6*d.*	5*s* and 2*s.* 6*d.*	Report, annually.
London: South London Entomological and Natural History Society 1872	Hibernia Chambers, London Bridge, S.E. Stanley Edwards, F.L.S., and H. J. Turner	165	2*s.* 6*d.*	7*s.* 6*d.*	Proceedings, annually.
Maidstone and Mid-Kent Natural History Society, 1868	Maidstone Museum. A. Barton and J. W. Bridge	96	None	10*s.*	Report, triennially.
Newcastle-upon-Tyne, Literary and Philosophical Society of, 1793	Newcastle-upon-Tyne. Alfred Holmes and Frederick Emley	3,000	None	1*l.* 1*s.*	—
Penzance Natural History and Antiquarian Society, 1839	Public Buildings, Penzance. J. B. Cornish	50	None	10*s.* 6*d.*	Transactions, occasionally.
Preston Scientific Society, 1893	Lecture Hall, 119A Fishergate, Preston. F. Chadderton	400	None	5*s.*	Papers, occasionally.
Scarborough Philosophical and Archæological Society, 1828	E. Arnold Wallis, Springfield, Scarborough	93	None	1*l.* and 10*s.*	Report, annually.
School Nature Study Union, 1903	H. E. Turner, 1 Grosvenor Park, Camberwell, S.E.	1,500	None	2*s.* 6*d.*	'School Nature Study,' five times a year.
Scottish Microscopical Society, 1888	Philosophical Institution, 4 Queen Street, Edinburgh. Dr. W. G. Aitchison Robertson	65	None	10*s.* 6*d.*	Proceedings, occasionally.
Southport Society of Natural Science, 1890	G. H. Hibbott, 156 Sussex Road, Southport	270	None	5*s.*	Report, annually.
Teign Naturalists' Field Club, 1858	John S. Amery, Druid, Ashburton, Devon	120	None	2*s.* 6*d.*	Report, annually.
Tunbridge Wells Natural History and Philosophical Society, 1884	D. Davies, M.B., 8 Lonsdale Gardens, Tunbridge Wells	147	None	10*s.* 6*d.* and 5*s*	—
Warrington Field Club, 1894	Alf. J. Jolley, 16 Arpley Street, Warrington	44	None	2*s.*	—
Watford Camera Club, 1902	F. H. Haines, 100 High Street, Watford	60	None	10*s.* and 5*s.*	—

Catalogue of the more important Papers, especially those referring to Local Scientific Investigations, published by the Corresponding Societies during the year ending May 31, 1911.

⁂ This Catalogue contains only the titles of papers published in the volumes or parts of the publications of the Corresponding Societies sent to the Secretary of the Committee in accordance with Rule 2.

Section A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Aiken, Rev. J. J. M. L. Continuous Daylight. 'History Berwickshire Nat. Club,' xx. 323–325. 1910.

Aldridge, Edward G. The Remarkable Weather of April in the United States. 'Selborne Magazine,' xxi. 170–172. 1910.

Andson, Rev. W. The Weather of 1908. 'Trans. Dumfriesshire and Galloway N. H. A. Soc.,' xxi. 93–98. 1910.

Banfield, A. C. Note on a Sliding Nose-piece for use in Stereo-photomicrography. 'Journal Quekett Mic. Club,' xi. 121–122. 1910.

Barr, J. Miller. Some Interesting Binary Stars. 'Journal Roy. Astr. Soc. of Canada,' iv. 261–266. 1910.

Campbell, W. W. Water Vapour on Mars. 'Journal Roy. Astr. Soc. of Canada,' iv. 212–213. 1910.

—— Some Preliminary Results deduced from observed Radial Velocities of Stars. 'Journal Roy. Astr. Soc. of Canada,' iv. 353–355. 1910.

Cannon, J. B. The Orbit of φ Persei. 'Journal Roy. Astr. Soc. of Canada,' iv. 195–203. 1910.

—— The Elements of 93 Leonis. 'Journal Roy. Astr. Soc. of Canada,' iv. 452–459. 1911.

Caradoc and Severn Valley Field Club. Meteorological Notes. 'Record of Bare Facts,' No. 20, 28–43. 1911.

Carson, P. A. Precise Measuring with Invar Wires: and the Measurement of Kootenay Base. 'Journal Roy. Astr. Soc. of Canada,' v. 36–58. 1911.

Chant, C. A. The Mount Wilson Conference of the Solar Union. 'Journal Roy. Astr. Soc. of Canada,' iv. 356–372. 1910.

Cole, Rev. E. Maule. The Recent Cloud-burst on the Yorkshire Wolds. 'The Naturalist' for 1910, 255–256. 1910.

Craw, J. H. Account of Rainfall in Berwickshire—year 1908. 'History Berwickshire Nat. Club,' xx. 328. 1910.

—— Account of Temperature at West Foulden—year 1908. 'History Berwickshire Nat. Club,' xx. 329. 1910.

Cresswell, Alfred. Records of Meteorological Observations taken at the Observatory, Edgbaston, 1910. 'Birm. and Mid. Inst. Sci. Soc.,' 25 pp. 1911.

De Lury, A. T. Presidential Address: The Evolution of Worlds. 'Journal Roy. Astr. Soc. of Canada,' v. 1–15. 1911.

De Lury, Ralph E. Changes in Focus produced by Plane Gratings. 'Journal Roy. Astr. Soc. of Canada,' v. 26–32. 1911.

—— A Device for Guiding the Image produced by a Cœlostat Telescope. 'Journal Roy. Astr. Soc. of Canada,' v. 33–35. 1911.

Dumfriesshire and Galloway N. H. A. Soc. Rainfall Records for the Southern Counties for the year 1909. 'Trans. Dumfriesshire and Galloway N. H. A. Soc.,' xxi. 210–213. 1910.

Gray, Dr. J. G., and A. D. Ross. On an Improved Form of Electric Furnace for use in Magnetic Testing. 'Proc. Glasgow R. Phil. Soc.,' xli. 84–90. 1910.

Gregory, Prof. J. W. (Min. Inst. Scotland). The Glasgow Earthquake of December 14, 1910, in relation to Mining. 'Trans. Inst. Min. Eng.,' xli. 55–63. 1911.

Halbaum, H. W. G. Some Memoranda concerning Coal-dust and the Essential Principles of the Coal-dust Theory. 'Trans. Inst. Min. Eng.,' xxxix. 728–739. 1910.

Harper, W. E. The Orbit of η Boötis. 'Journal Roy. Astr. Soc. of Canada,' iv. 191–194. 1910.

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1901. ‡Adam, J. Miller. 15 Walmer-crescent, Glasgow.
1887. ‡ADAMI, J. G., M.A., M.D., F.R.S., Professor of Pathology in McGill University, Montreal, Canada.
1901. §Adams, John, M.A., Professor of Education in the University of London. 23 Tanza-road, Hampstead, N.W.
1904. ‡Adams, W. G. S., M.A. Department of Agriculture, Upper Merrion-street, Dublin.
1869. *ADAMS, WILLIAM GRYLLS, M.A., D.Sc., F.R.S., F.G.S., F.C.P.S. (Pres. A, 1880; Council, 1878–85.) Heathfield, Broadstone, Dorset.
1908. §Adamson, R. Stephen. Emmanuel College, Cambridge.
1898. ‡Addison, William L. T. Byng Inlet, Ontario, Canada.
1890. ‡ADENEY, W. E., D.Sc., F.C.S. Royal University of Ireland, Earlsfort-terrace, Dublin.
1899. *Adie, R. H., M.A., B.Sc. 136 Huntingdon-road, Cambridge.
1908. §Adkin, Robert. 4 Lingard's-road, Lewisham, S.E.
1905. ‡Adle, Henry. P.O. Box 1059, Johannesburg.
1908. *Agar, W. E., M.A. Natural History Department, The University, Glasgow.
1902. ‡Agnew, Samuel, M.D. Bengal-place, Lurgan.
1909. ‡Aikins, J. Somerset. 426 Assiniboine-avenue, Winnipeg, Canada.
1906. §Aikman, J. A. 6 Glencairn-crescent, Edinburgh.
1871. *Ainsworth, John Stirling. Harecroft, Gosforth, Cumberland.
1909. *AIRD, JOHN. Canadian Bank of Commerce, Winnipeg, Canada.
1911. §Airey, John R., M.A., B.Sc. Rugby House, Marley, Yorkshire.
1895. *Airy, Hubert, M.D. Stoke House, Woodbridge, Suffolk.
1891. *Aisbitt, M. W. Mountstuart-square, Cardiff.
1871. §AITKEN, JOHN, LL.D., F.R.S., F.R.S.E. Ardenlea, Falkirk, N.B.
1901. ‡Aitken, Thomas, M.Inst.C.E. County Buildings, Cupar-Fife.
1884. *Alabaster, H. Milton, Grange-road, Sutton, Surrey.
1886. *Albright, G. S. Broomsberrow Place, Ledbury.
1905. ‡Albright, Miss. Finstal Farm, Finstal, Bromsgrove, Worcestershire.
1907. ‡*Alcock, N. H., M.D., D.Sc. 22 Downshire-hill, Hampstead, N.W.*
1900. *Aldren, Francis J., M.A. The Lizans, Malvern Link.
1896. §Aldridge, J. G. W., Assoc.M.Inst.C.E. 39 Victoria-street, Westminster, S.W.
1905. *Alexander, J. Abercromby, F.S.A. 24 Lawn-crescent, Kew.
1888. *Alexander, Patrick Y. 3 Whitehall-court, S.W.
1910. §Alexander, W. B., B.A. King's College, Cambridge.
1891. *Alford, Charles J., F.G.S. Hôtel Angleterre, Vevey, Switzerland.
1883. ‡Alger, W. H. The Manor House, Stoke Damerel, South Devon.
1883. ‡Alger, Mrs. W. H. The Manor House, Stoke Damerel, South Devon.
1901. *Allan, James A. 21 Bothwell-street, Glasgow.
1904. *Allcock, William Burt. Emmanuel College, Cambridge.
1879. *Allen, Rev. A. J. C. 34 Lensfield-road, Cambridge.
1898. §ALLEN, Dr. E. J. The Laboratory, Citadel Hill, Plymouth.
1891. ‡Allen, H. A., F.G.S. 28 Jermyn-street, S.W.
1907. *Allorge, M. M., L. ès Sc., F.G.S. University Museum, Oxford.
1882. *Alverstone, The Right Hon. Lord, G.C.M.G., LL.D., F.R.S. Hornton Lodge, Hornton-street, Kensington, W.
1887. ‡Alward, G. L. Enfield Villa, Waltham, Grimsby, Yorkshire.
1883. §Amery, John Sparke. Druid, Ashburton, Devon.
1884. ‡AMI, HENRY, M.A., D.Sc., F.G.S. Geological Survey, Ottawa, Canada.

Year of Election.

1909. ‡Ami, H. M., M.D. Ottawa, Canada.
1905. ‡Anderson, A. J., M.A., M.B. The Residency, Portswood-road, Green Point, Cape Colony.
1910. §Anderson, Alexander. Tower House, Dore, near Sheffield.
1906. *Anderson, C. L. P.O. Box 2162, Johannesburg.
1908. ‡Anderson, Edgar. Glenavon, Merrion-road, Dublin.
1885. *ANDERSON, HUGH KERR, M.A., M.D., F.R.S. Caius College, Cambridge.
1901. *Anderson, James. 10 Albion-crescent, Dowanhill, Glasgow.
1892. ‡Anderson, Joseph, LL.D. 8 Great King-street, Edinburgh.
1899. *Anderson, Miss Mary Kerr. 13 Napier-road, Edinburgh.
1888. *Anderson, R. Bruce. 5 Westminster-chambers, S.W.
1887. ‡ANDERSON, Professor R. J., M.D., F.L.S. Queen's College, and Atlantic Lodge, Salthill, Galway.
1905. ‡Anderson, T. J. P.O. Box 173, Cape Town.
1880. *ANDERSON, TEMPEST, M.D., D.Sc., F.G.S. (Council, 1907- ; Local Sec. 1881.) 17 Stonegate, York.
1901. *Anderson, Dr. W. Carrick. 7 Scott-street, Garnethill, Glasgow.
1908 ‡Anderson, William. Glenavon, Merrion-road, Dublin.
1911. §Andrade, E. N. da C. University College, Gower Street, W.C.
1907. ‡Andrews, A. W. Adela-avenue, West Barnes-lane, New Malden, Surrey.
1909. ‡Andrews, Alfred J. Care of Messrs. Andrews, Andrews, & Co., Winnipeg, Canada.
1895. ‡ANDREWS, CHARLES W., B.A., D.Sc., F.R.S. British Museum (Natural History), S.W.
1909. ‡Andrews, G. W. 433 Main-street, Winnipeg, Canada.
1880. *Andrews, Thornton, M.Inst.C.E. Cefn Eithen, Swansea.
1886. §Andrews, William, F.G.S. Steeple Croft, Coventry.
1877. §ANGELL, JOHN, F.C.S., F.I.C. 6 Beacons-field, Derby-road, Withington, Manchester.
1896. ‡Annett, R. C. F., Assoc.Inst.C.E. 4 Buckingham-avenue, Sefton Park, Liverpool.
1886. ‡Ansell, Joseph. 27 Bennett's-hill, Birmingham.
1901. ‡Arakawa, Minozi. Japanese Consulate, 84 Bishopsgate-street Within, E.C.
1900. *Arber, E. A. Newell, M.A., F.L.S. 52 Huntingdon-road, Cambridge.
1904. *Arber, Mrs. E. A. Newell, D.Sc. 52 Huntingdon-road, Cambridge.
1894. ‡Archibald, A. Holmer, Court-road, Tunbridge Wells.
1884. *Archibald, E. Douglas. Constitutional Club, W.C.
1909. §Archibald, Professor E. H. Bowne Hall of Chemistry, Syracuse University, Syracuse, New York, U.S.A.
1909. §Archibald, H. Care of Messrs. Machray, Sharpe, & Dennistoun, Bank of Ottawa Chambers, Winnipeg, Canada.
1883. *Armistead, William. Hillcrest, Oaken, Wolverhampton.
1908. ‡Armstrong, E. C. R., M.R.I.A., F.R.G.S. Cyprus, Eglinton-road, Dublin.
1903. *ARMSTRONG, E. FRANKLAND, D.Sc., Ph.D. 98 London-road, Reading.
1873. *ARMSTRONG, HENRY E., Ph.D., LL.D., F.R.S. (Pres. B, 1885, 1909; Pres. L, 1902; Council, 1899-1905, 1909-), Professor of Chemistry in the City and Guilds of London Institute, Central Institution, Exhibition-road, S.W. 55 Granville-park, Lewisham, S.E.
1909. ‡Armstrong, Hon. Hugh. Parliament Buildings, Kennedy-street, Winnipeg, Canada.

Year of Election

1905. ‡Armstrong, John. Kamfersdam Mine, near Kimberley, Cape Colony.
1905. §ARNOLD, J. O., Professor of Metallurgy in the University of Sheffield.
1893. *ARNOLD-BEMROSE, H. H., Sc.D., F.G.S. Ash Tree House, Osmaston-road, Derby.
1904. ‡Arunachalam, P. Ceylon Civil Service, Colombo, Ceylon.
1870. *Ash, Dr. T. Linnington. Penroses, Holsworthy, North Devon.
1903. *Ashby, Thomas. The British School, Rome.
1909. ‡Ashdown, J. H. 337 Broadway, Winnipeg, Canada.
1911. §Ashley, Herbert, M.Inst.C.E. Portsmouth Water Works Company, Engineer's Office, Commercial-road, Portsmouth.
1907. ‡ASHLEY, W. J., M.A. (Pres. F, 1907), Professor of Commerce in the University of Birmingham. 3 Yateley-road, Edgbaston, Birmingham.
Ashworth, Henry. Turton, near Bolton.
1903. *Ashworth, J. H., D.Sc. 4 Cluny-terrace, Edinburgh.
1890. ‡Ashworth, J. Reginald, D.Sc. 105 Freehold-street, Rochdale.
1905. ‡Askew, T. A. Main-road, Claremont, Cape Colony.
1875. *Aspland, W. Gaskell. 50 Park Hill-road, N.W.
1896. *Assheton, Richard, M.A., F.L.S. Grantchester, Cambridge.
1905. ‡Assheton, Mrs. Grantchester, Cambridge.
1908. §ASTLEY, Rev. H. J. DUKINFIELD, M.A., Litt.D. East Rudham Vicarage, King's Lynn.
1903. ‡Atchison, Arthur F. T., B.Sc. Royal Engineering College, Cooper's Hill, Staines.
1898. *Atkinson, E. Cuthbert. 5 Pembroke-vale, Clifton, Bristol.
1894. *Atkinson, Harold W., M.A. West View, Eastbury-avenue, Northwood, Middlesex.
1906. ‡Atkinson, J. J. Cosgrove Priory, Stony Stratford.
1881. ‡Atkinson, J. T. The Quay, Selby, Yorkshire.
1907. ‡Atkinson, Robert E. Morland-avenue, Knighton, Leicester.
1881. ‡ATKINSON, ROBERT WILLIAM, F.C.S., F.I.C. (Local Sec. 1891.) 44 Stuart-street, Cardiff.
1906. §AUDEN, G. A., M.A., M.D. The Education Office, Edmund-street, Birmingham.
1907. §Auden, H. A., D.Sc. 13 Broughton-drive, Grassendale, Liverpool.
1903. ‡AUSTIN, CHARLES E. 37 Cambridge-road, Southport.
1853. *AVEBURY, The Right Hon. Lord, D.C.L., F.R.S. (PRESIDENT, 1881; TRUSTEE, 1872- ; Pres. D, 1872; Council, 1865-71.) High Elms, Farnborough, Kent.
1909. ‡Axtell, S. W. Stobart Block, Winnipeg, Canada.

1883. *Bach-Gladstone, Madame Henri. 147 Rue de Grenelle, Paris.
1906. ‡Backhouse, James. Daleside, Scarborough.
1883. *Backhouse, W. A. St. John's, Wolsingham, R.S.O., Durham.
1887. *Bacon, Thomas Walter. Ramsden Hall, Billericay, Essex.
1903. ‡Baden-Powell, Major B. 32 Prince's-gate, S.W.
1907. §Badgley, Colonel W. F., Assoc.Inst.C.E., F.R.G.S. Verecroft, Devizes.
1908. *Bagnall, Richard Siddoway. Penshaw Lodge, Penshaw, Co. Durham.
1905. ‡Baikie, Robert. P.O. Box 36, Pretoria, South Africa.
1883. ‡Baildon, Dr. 42 Hoghton-street, Southport.
1883. *Bailey, Charles, M.Sc., F.L.S. Haymesgarth, Cleeve Hill S.O., Gloucestershire.

Year of Election.

1893. ‡BAILEY, Colonel F., F.R.G.S. 7 Drummond-place, Edinburgh.
1887. *Bailey, G. H., D.Sc., Ph.D. Edenmor, Kinlochleven, Argyll, N.B.
1905. *Bailey, Harry Percy. 22 Clarendon-road, Margate.
1905. ‡Bailey, Right Hon. W. F., C.B. Land Commission, Dublin.
1894. *BAILY, FRANCIS GIBSON, M.A. Newbury, Colinton, Midlothian.
1878. ‡BAILY, WALTER. 4 Roslyn-hill, Hampstead, N.W.
1905. *Baker, Sir Augustine. 56 Merrion-square, Dublin.
1910. §Baker, H. F., Sc.D., F.R.S. St. John's College, Cambridge.
1886. §Baker, Harry, F.I.C. Epworth House, Moughland-lane, Runcorn.
1911. §Baker, Miss Lilian, M.Sc. Queen's-avenue, Tunstall, Staffordshire.
1907. ‡Baldwin, Walter. 5 St. Alban's-street, Rochdale.
1904. ‡BALFOUR, The Right Hon. A. J., D.C.L., LL.D., M.P., F.R.S., Chancellor of the University of Edinburgh. (PRESIDENT, 1904.) Whittingehame, Prestonkirk, N.B.
1894. ‡BALFOUR, HENRY, M.A. (Pres. H, 1904.) Langley Lodge, Headington Hill, Oxford.
1905. ‡Balfour, Mrs. H. Langley Lodge, Headington Hill, Oxford.
1875. ‡BALFOUR, ISAAC BAYLEY, M.A., D.Sc., M.D., F.R.S., F.R.S.E., F.L.S. (Pres. D, 1894 ; K, 1901), Professor of Botany in the University of Edinburgh. Inverleith House, Edinburgh.
1883. ‡Balfour, Mrs. I. Bayley. Inverleith House, Edinburgh.
1905. ‡Balfour, Mrs. J. Dawyck, Stobo, N.B.
1905. ‡Balfour, Lewis. 11 Norham-gardens, Oxford.
1905. ‡Balfour, Miss Vera B. Dawyck, Stobo, N.B.
1878. *Ball, Sir Charles Bent, Bart., M.D., Regius Professor of Surgery in the University of Dublin. 24 Merrion-square, Dublin.
1866. *BALL, Sir ROBERT STAWELL, LL.D., F.R.S., F.R.A.S. (Pres. A, 1887 ; Council, 1884–90, 1892–94 ; Local Sec. 1878), Lowndean Professor of Astronomy and Geometry in the University of Cambridge. The Observatory, Cambridge.
1908. ‡Ball, T. Elrington. 6 Wilton-place, Dublin.
1883. *Ball, W. W. Rouse, M.A. Trinity College, Cambridge.
1905. ‡*Ballantine, Rev. T. R. Tirmochree, Bloomfield, Belfast.*
1869. ‡Bamber, Henry K., F.C.S. 5 Westminster-chambers, Victoria-street, Westminster, S.W.
1890. ‡Bamford, Professor Harry, M.Sc. 30 Falkland-mansions, Glasgow.
1909. §Bampfield, Mrs. E. 309 Donald-street, Winnipeg, Canada.
1905. ‡Banks, Miss Margaret Pierrepont. 10 Regent-terrace, Edinburgh.
1898. ‡Bannerman, W. Bruce, F.S.A. The Lindens, Sydenham-road, Croydon.
1909. ‡Baragar, Charles A. University of Manitoba, Winnipeg, Canada.
1910. §Barber, Miss Mary. 51 Nevern-square, S.W.
1890. *Barber-Starkey, W. J. S. Aldenham Park, Bridgnorth, Salop.
1861. *Barbour, George. Bolesworth Castle, Tattenhall, Chester.
1860. *Barclay, Robert. High Leigh, Hoddesden, Herts.
1887. *Barclay, Robert. Sedgley New Hall, Prestwich, Manchester.
1902. ‡Barcroft, H., D.L. The Glen, Newry, Co. Down.
1902. ‡BARCROFT, JOSEPH, M.A., B.Sc., F.R.S. King's College, Cambridge.
1911. §Barger, George, M.A., D.Sc. 107 Tyrwhitt-road, St. John's, S.E.
1904. §Barker, B. T. P., M.A. Fenswood, Long Ashton, Bristol.
1906. *Barker, Geoffrey Palgrave. Henstead Hall, Wrentham, Suffolk.
1899. §Barker, John H., M.Inst.C.E. Adderley Park Rolling Mills, Birmingham.
1882. *Barker, Miss J. M. Care of Mrs. Plummer, Prior's-terrace, Tynemouth.
1910. *Barker, Raymond Inglis Palgrave. Henstead Hall, Wrentham, Suffolk.

Year of Election

1909. ‡Barlow, Lieut.-Colonel G. N. H. Care of Messrs. Cox & Co., 16 Charing Cross, S.W.
1889. ‡Barlow, H. W. L., M.A., M.B., F.C.S. The Park Hospital, Hither Green, S.E.
1883. ‡Barlow, J. J. 84 Cambridge-road, Southport.
1885. *BARLOW, WILLIAM, F.R.S., F.G.S. The Red House, Great Stanmore.
1905. *Barnard, Miss Annie T., M.D., B.Sc. 32 Chenies-street-chambers, Gower-street, W.C.
1902. §Barnard, J. E. Park View, Brondesbury Park, N.W.
1881. *Barnard, William, LL.B. 3 New-court, Lincoln's Inn, W.C.
1904. ‡Barnes, Rev. E. W., M.A., Sc.D., F.R.S. Trinity College, Cambridge.
1907. §Barnes, Professor H. T., Sc.D., F.R.S. McGill University, Montreal, Canada.
1909. *Barnett, Miss Edith A. Holm Leas, Worthing.
1881. ‡BARR, ARCHIBALD, D.Sc., M.Inst.C.E., Professor of Civil Engineering in the University, Glasgow.
1902. *Barr, Mark. Gloucester-mansions, Harrington-gardens, S.W.
1904. ‡Barrett, Arthur. 6 Mortimer-road, Cambridge.
1872. *BARRETT, Sir W. F., F.R.S., F.R.S.E., M.R.I.A. 6 De Vesci-terrace, Kingstown, Co. Dublin.
1874. *BARRINGTON, R. M., M.A., LL.B., F.L.S. Fassaroe, Bray, Co. Wicklow.
1874. *Barrington-Ward, Rev. Mark J., M.A., F.L.S., F.R.G.S. The Rectory, Duloe S.O., Cornwall.
1893. *BARROW, GEORGE, F.G.S. 28 Jermyn-street, S.W.
1896. §Barrowman, James. Staneacre, Hamilton, N.B.
1908. ‡Barry, Gerald H. Wiglin Glebe, Carlow, Ireland.
1884. *Barstow, Miss Frances A. Garrow Hill, near York.
1890. *Barstow, J. J. Jackson. The Lodge, Weston-super-Mare.
1890. *Barstow, Mrs. The Lodge, Weston-super-Mare.
1892. ‡Bartholomew, John George, F.R.S.E., F.R.G.S. Newington House, Edinburgh.
1858. *Bartholomew, William Hamond, M.Inst.C.E. Ridgeway House, Cumberland-road, Hyde Park, Leeds.
1909. ‡Bartleet, Arthur M. 138 Hagley-road, Edgbaston, Birmingham.
1909. ‡Bartlett, C. Bank of Hamilton-building, Winnipeg, Canada.
1893. *Barton, Edwin H., D.Sc., F.R.S.E., Professor of Experimental Physics in University College, Nottingham.
1908. ‡Barton, Rev. Walter John, B.A., F.R.G.S. The College, Winchester.
1904. *Bartrum, C. O., B.Sc. 32 Willoughby-road, Hampstead, N.W.
1845. *Bashforth, Rev. Francis, B.D. Woodhall Spa, Lincoln.
1888. *BASSET, A. B., M.A., F.R.S. Fledborough Hall, Holyport, Berkshire.
1891. ‡Bassett, A. B. Cheverell, Llandaff.
1866. *BASSETT, HENRY. 26 Belitha-villas, Barnsbury, N.
1911. *Bassett, Henry, jun., D.Sc., Ph.D. Holly House, Broughton, Kettering.
1889. ‡BASTABLE, Professor C. F., M.A., F.S.S. (Pres. F, 1894.) 6 Trevelyan-terrace, Rathgar, Co. Dublin.
1871. ‡BASTIAN, H. CHARLTON, M.A., M.D., F.R.S., F.L.S., Emeritus Professor of the Principles and Practice of Medicine in University College, London. Fairfield, Chesham Bois, Bucks.
1883. ‡BATEMAN, Sir A. E., K.C.M.G. Woodhouse, Wimbledon Park, S.W.
1905. *Bateman, Mrs. F. D. Kilmorie, Ilsham-drive, Torquay, Devon.
1907. *BATEMAN, HARRY. The University, Manchester.
1884. ‡BATESON, Professor WILLIAM, M.A., F.R.S. (Pres. D, 1904.) Manor House, Merton, Surrey.

Year of Election.

1881. *BATHER, FRANCIS ARTHUR, M.A., D.Sc., F.R.S., F.G.S. British Museum (Natural History), S.W.
1906. §Batty, Mrs. Braithwaite. Ye Gabled House, The Parks, Oxford.
1904. ‡Baugh, J. H. Agar. 92 Hatton-garden, E.C.
1909. §Bawlf, Nicholas. Assiniboine-avenue, Winnipeg, Canada.
1905. ‡Baxter, W. Duncan. P.O. Box 103, Cape Town.
1876. *BAYNES, ROBERT E., M.A. Christ Church, Oxford.
1887. *Baynes, Mrs. R. E. 2 Norham-gardens, Oxford.
1883. *Bazley, Gardner S. Hatherop Castle, Fairford, Gloucestershire.
Bazley, Sir Thomas Sebastian, Bart., M.A. Kilmorie, Ilsham-drive, Torquay, Devon.
1909. *BEADNELL, H. J. LLEWELLYN, F.G.S. Rhydlorwernon, Brecon.
1889. §BEARE, Professor T. HUDSON, B.Sc., F.R.S.E., M.Inst.C.E. The University, Edinburgh.
1905. ‡Beare, Mrs. T. Hudson. 10 Regent-terrace, Edinburgh.
1904. §Beasley, H. C. 25A Prince Alfred-road, Wavertree, Liverpool.
1905. ‡Beattie, Professor J. C., D.Sc., F.R.S.E. South African College, Cape Town.
1910. ‡Beattie, James M. 12 Caxton-road, Sheffield.
1900. ‡Beaumont, Professor Roberts, M.I.Mech.E. The University, Leeds.
1887. *Beaumont, W. J. The Laboratory, Citadel Hill, Plymouth.
1885. *BEAUMONT, W. W., M.Inst.C.E. Outer Temple, 222 Strand, W.C.
1887. *BECKETT, JOHN HAMPDEN. Corbar Hall, Buxton, Derbyshire.
1904. §Beckit, H. O. Cheney Cottage, Headington, Oxford.
1885. ‡BEDDARD, FRANK E., M.A., F.R.S., F.Z.S., Prosector to the Zoological Society of London, Regent's Park, N.W.
1911. §Beddow, Fred, D.Sc., Ph.D. 2 Pier-mansions, Southsea.
1904. *Bedford, T. G., M.A. 13 Warkworth-street, Cambridge.
1891. ‡Bedlington, Richard. Gadlys House, Aberdare.
1878. ‡BEDSON, P. PHILLIPS, D.Sc., F.C.S. (Local Sec. 1889), Professor of Chemistry in the College of Physical Science, Newcastle-upon-Tyne.
1901. *BEILBY, G. T., LL.D., F.R.S. (Pres. B, 1905.) 11 University-gardens, Glasgow.
1905. ‡Beilby, Hubert. 11 University-gardens, Glasgow.
1891. *Belinfante, L. L., M.Sc., Assist. Sec. G.S. Burlington House, W.
1909. ‡BELL, C. N. (Local Sec. 1909.) 121 Carlton-street, Winnipeg, Canada.
1894. ‡BELL, F. JEFFREY, M.A., F.Z.S. British Museum, S.W.
1900. *Bell, Henry Wilkinson. Beech Cottage, Rawdon, near Leeds.
1870. *BELL, J. CARTER, A.R.S.M. The Cliff, Higher Broughton, Manchester.
1883. *Bell, John Henry. 102 Leyland-road, Southport.
1905. ‡Bell, W. H. S. P.O. Box 4284, Johannesburg.
1888. *Bell, Walter George, M.A. Trinity Hall, Cambridge.
1908. *Bellamy, Frank Arthur, M.A., F.R.A.S. University Observatory, Oxford.
1904. ‡Bellars, A. E. Magdalene College, Cambridge.
1905. ‡Bender, Rev. A. P., M.A. Synagogue House, Cape Town.
1883. *Bennett, Laurence Henry. The Elms, Paignton, South Devon.
1901. ‡Bennett, Professor Peter. 207 Bath-street, Glasgow.
1909. *Bennett, R. B., K.C. Calgary, Alberta, Canada.
1905. §Benson, Arthur H., M.A., F.R.C.S.I. 42 Fitzwilliam-square, Dublin.
1905. §Benson, Mrs. A. H. 42 Fitzwilliam-square, Dublin.
1909. ‡Benson, Miss C. C. Terralta, Port Hope, Ontario, Canada.
1903. §Benson, D. E. Queenwood, 12 Irton-road, Southport.
1901. *Benson, Miss Margaret J., D.Sc. Royal Holloway College, Egham.

Year of Election.

1887. *Benson, Mrs. W. J. 5 Wellington-court, Knightsbridge, S.W.
1898. *Bent, Mrs. Theodore. 13 Great Cumberland-place, W.
1904. ‡Bentley, B. H., M.A., Professor of Botany in the University of Sheffield.
1905. *Bentley, Wilfred. Rein Wood, Huddersfield.
1908. ‡Benton, Mrs. Evelyn M. Kingswear, Hale, Altrincham, Cheshire.
1896. *Bergin, William, M.A., Professor of Natural Philosophy in University College, Cork.
1894. §BERKELEY, The Earl of, F.R.S., F.C.S. (Council, 1909-10.) Foxcombe, Boarshill, near Abingdon.
1905. *BERNACCHI, L. C., F.R.G.S. Pound Farm, Upper Long Ditton, Surrey.
1906. *Bernays, Albert Evan. 3 Priory-road, Kew, Surrey.
1898. §Berridge, Miss C. E. 107 Albert Palace-mansions, Battersea Park, S.W.
1894. §BERRIDGE, DOUGLAS, M.A., F.C.S. The College, Malvern.
1908. *Berridge, Miss Emily M. Dunton Lodge, The Knoll, Beckenham.
1908. *Berry, Arthur J. 5 University-gardens, Glasgow.
1904. §Berry, R. A., Ph.D., West of Scotland Agricultural College, 6 Blythswood-square, Glasgow.
1905. ‡Bertrand, Captain Alfred. Champel, Geneva.
1862. ‡BESANT, WILLIAM HENRY, M.A., Sc.D., F.R.S. St. John's College, Cambridge.
1880. *BEVAN, Rev. JAMES OLIVER, M.A., F.S.A., F.G.S. Chillenden Rectory, Canterbury.
1904. *Bevan, Professor P. V., M.A. Hillside, Egham.
1906. ‡*Bevan-Lewis, W., M.D. West Riding Asylum, Wakefield.*
1884. *Beverley, Michael, M.D. 54 Prince of Wales-road, Norwich.
1911. §Bevis, Lieut.-Colonel C. W. Elm Grove House, Southsea.
1903. ‡Bickerdike, C. F. 1 Boverney-road, Honor Oak Park, S.E.
1888. *Bidder, George Parker. Savile Club, Piccadilly, W.
1910. ‡Biddlecombe, A. 50 Grainger-street, Newcastle-on-Tyne.
1904. §BIGG-WITHER, Colonel A. C., F.R.A.S. Tilthams, Godalming, Surrey.
1882. ‡*Biggs, C. H. W., F.C.S. Glebe Lodge, Champion-hill, S.E.*
1911. §BILES, J. H., LL.D., D.Sc. (Pres. G., 1911), Professor of Naval Architecture in the University of Glasgow. 10 University-gardens, Glasgow.
1898. ‡Billington, Charles. Heimath, Longport, Staffordshire.
1901. *Bilsland, Sir William, Bart., J.P. 28 Park-circus, Glasgow.
1908. *Bilton, Edward Barnard. Graylands, Wimbledon Common, S.W.
1887. *Bindloss, James B. Elm Bank, Buxton.
1909. §Bingham, Alexander R. 16 Kingsmead-road South, Birkenhead.
1884. *Bingham, Colonel Sir John E., Bart. West Lea, Ranmoor, Sheffield.
1881. ‡BINNIE, Sir ALEXANDER R., M.Inst.C.E., F.G.S. (Pres. G, 1900.) 77 Ladbroke-grove, W.
1910. *Birchenough, C., M.A. 8 Severn-road, Sheffield.
1887. *Birley, H. K. Penrhyn, Irlams o' th' Height, Manchester.
1904. ‡Bishop, A. W. Edwinstowe, Chaucer-road, Cambridge.
1911. *Bishop, Major C. F., R.A. The Castle, Tynemouth, Northumberland.
1906. §Bishop, J. L. Customs and Excise Office, Leeds.
1894. ‡Bisset, James, F.R.S.E. 9 Greenhill-park, Edinburgh.
1910. ‡Bisset, John. Thornhill, Insch, Aberdeenshire.
1886. *Bixby, General W. H. 735 Southern-building, Washington, U.S.A.
1909. ‡Black, W. J., Principal of Manitoba Agricultural College, Winnipeg, Canada.
1901. §Black, W. P. M. 136 Wellington-street, Glasgow.
1903. *BLACKMAN, F. F., M.A., D.Sc., F.R.S. (Pres. K, 1908.) St. John's College, Cambridge.

Year of Election.

1908. §BLACKMAN, Professor V. H., M.A., Sc.D. Imperial College of Science and Technology, S.W.
1909. ‡Blaikie, Leonard, M.A. Civil Service Commission, Burlington-gardens, W.
1910. ‡Blair, R., M.A. London County Council, Spring-gardens, S.W.
1902. ‡Blake, Robert F., F.I.C. Queen's College, Belfast.
1900. *Blamires, Joseph. Bradley Lodge, Huddersfield.
1905. ‡Blamires, Mrs. Bradley Lodge, Huddersfield.
1904. ‡Blanc, Dr. Gian Alberto. Istituto Fisico, Rome.
1884. *Blandy, William Charles, M.A. 1 Friar-street, Reading.
1887. *Bles, Edward J., M.A., D.Sc. The Mill House, Iffley, Oxford.
1884. *Blish, William G. Niles, Michigan, U.S.A.
1902. ‡Blount, Bertram, F.I.C. 76 & 78 York-street, Westminster, S.W.
1888. ‡Bloxsom, Martin, B.A., M.Inst C.E. Hazelwood, Crumpsall Green, Manchester.
1909. §Blumfeld, Joseph, M.D. 7 Cavendish-place, W.
Blyth, B. Hall. 135 George-street, Edinburgh.
1887. *Boddington, Henry. Pownall Hall, Wilmslow, Manchester.
1908. §BOEDDICKER, OTTO, Ph.D. Birr Castle Observatory, Birr, Ireland.
1887. *Boissevain, Gideon Maria. 4 Tesselschade-straat, Amsterdam.
1911. §Bolland, B. G. C. Department of Agriculture, Cairo, Egypt.
1898. §BOLTON, H., F.R.S.E. The Museum, Queen's-road, Bristol.
1894. §BOLTON, JOHN. 15 Cranley-gardens, Muswell Hill, N.
1898. *BONAR, JAMES, M.A., LL.D. (Pres. F, 1898 ; Council, 1899–1905.) The Mint, Ottawa, Canada.
1909. ‡Bonar, Thomson, M.D. 114 Via Babuino, Piazza di Spagna, Rome.
1909. ‡Bond, J. H. R., M.B. 167 Donald-street, Winnipeg, Canada.
1908. ‡BONE, Professor W. A., D.Sc., F.R.S. The University, Leeds.
1871. *BONNEY, Rev. THOMAS GEORGE, Sc.D., LL.D., F.R.S., F.S.A., F.G.S. (PRESIDENT, 1910 ; SECRETARY, 1881-85 ; Pres. C, 1886.) 9 Scroope-terrace, Cambridge.
1911. ‡Bonny, W. Naval Store office, The Dockyard, Portsmouth.
1888. ‡Boon, William. Coventry.
1893. ‡Boot, Sir Jesse. Carlyle House, 18 Burns-street, Nottingham.
1890. *BOOTH, Right Hon. CHARLES, D.Sc., F.R.S., F.S.S. 28 Campden House Court, Kensington, W.
1883. ‡Booth, James. Hazelhurst, Turton.
1910. §Booth, John, B.Sc. 25 Rathdown-street, Carlton, Melbourne, Australia.
1908. §Booth, Robert, J.P. Bartra Hall, Dalkey, Co. Dublin.
1883. ‡Boothroyd, Benjamin. Weston-super-Mare.
1901. *Boothroyd, Herbert E., M.A., B.Sc. Sidney Sussex College, Cambridge.
1882. §BORNS, HENRY, Ph.D., F.C.S. 5 Sutton Court-road, Chiswick, W.
1901. ‡Borradaile, L. A., M.A. Selwyn College, Cambridge.
1876. *BOSANQUET, R. H. M., M.A., F.R.S., F.R.A.S. Castillo Zamora, Realejo-Alto, Teneriffe.
1903. *BOSANQUET, ROBERT C., M.A., Professor of Classical Archæology in the University of Liverpool. Institute of Archæology, 40 Bedford-street, Liverpool.
1896. ‡Bose, Professor J. C., C.I.E., M.A., D.Sc. Calcutta, India.
1881. §BOTHAMLEY, CHARLES H., M.Sc., F.I.C., F.C.S., Education Secretary, Somerset County Council, Weston-super-Mare.
1871. *BOTTOMLEY, JAMES THOMSON, M.A., LL.D., D.Sc., F.R.S., F.R.S.E., F.C.S. 13 University-gardens, Glasgow.
1884. *Bottomley, Mrs. 13 University-gardens, Glasgow.
1892. *BOTTOMLEY, W. B., B.A., Professor of Botany in King's College, W.C.

Year of Election.
1909. §Boulenger, C. L. 8 Courtfield-road, S.W.
1905. §Boulenger, G. A., F.R.S. (Pres. D, 1905.) 8 Courtfield-road, S.W.
1905. §Boulenger, Mrs. 8 Courtfield-road, S.W.
1903. §Boulton, W. S., B.Sc., F.G.S., Professor of Geology in University College, Cardiff. 26 Archer-road, Penarth.
1911. §Bourdillon, R. Balliol College, Oxford.
1883. ‡Bourne, A. G., C.I.E., D.Sc., F.R.S., F.L.S. Adyar, Madras.
1893. *Bourne, G. C., M.A., D.Sc., F.R.S., F.L.S. (Pres. D, 1910; Council, 1903-09; Local Sec. 1894), Linacre Professor of Comparative Anatomy in the University of Oxford. Savile House, Mansfield-road, Oxford.
1904. **Bousfield, E. G. P. Clarendon Lodge, Blyth Bridge, Stoke-on-Trent.*
1884. ‡Bovey, Henry T., M.A., LL.D., F.R.S., M.Inst.C.E. 16 Hans-road, S.W.
1881. *Bower, F. O., D.Sc., F.R.S., F.R.S.E., F.L.S. (Pres. K, 1898; Council, 1900-06), Regius Professor of Botany in the University of Glasgow.
1898. *Bowker, Arthur Frank. F.R.G.S., F.G.S. Whitehill, Wrotham, Kent.
1856. *Bowlby, Miss F. E. 4 South Bailey, Durham.
1908. §Bowles, E. Augustus, M.A., F.L.S. Myddelton House, Waltham Cross, Herts.
1898. §Bowley, A. L., M.A. (Pres. F, 1906; Council, 1906-11.) Northcourt-avenue, Reading.
1880. ‡Bowly, Christopher. Cirencester.
1887. ‡Bowly, Mrs. Christopher. Cirencester.
1899. *Bowman, Herbert Lister, M.A., D.Sc., F.G.S., Professor of Mineralogy in the University of Oxford. Magdalen College, Oxford.
1899. *Bowman, John Herbert. Greenham Common, Newbury.
1887. §Box, Alfred Marshall. Woodlands, Magrath Avenue, Cambridge.
1901. ‡Boyd, David T. Rhinsdale, Ballieston, Lanark.
1892. ‡Boys, Charles Vernon, F.R.S. (Pres. A, 1903; Council, 1893-99, 1905-08.) 66 Victoria-street, S.W.
1872. *Brabrook, Sir Edward, C.B., F.S.A. (Pres. H, 1898; Pres. F, 1903; Council, 1903-10; 1911-). 178 Bedford-hill, Balham, S.W.
1894. *Braby, Ivon. Helena, Alan-road, Wimbledon, S.W.
1905. ‡Bradford, Wager. P.O. Box 5, Johannesburg.
1893. §Bradley, F. L. Ingleside, Malvern Wells.
1904. *Bradley, Gustav. Council Offices, Goole.
1899. *Bradley, J. W., Assoc.M.Inst.C.E. Westminster City Hall, Charing Cross-road, W.C.
1903. *Bradley, O. Charnock, D.Sc., M.D., F.R.S.E. Royal Veterinary College, Edinburgh.
1892. ‡Bradshaw, W. Carisbrooke House, The Park, Nottingham.
1863. ‡Brady, George S., M.D., LL.D., F.R.S. Park Hurst, Endcliffe, Sheffield.
1911. §Bragg, W. H., M.A., F.R.S., Professor of Mathematics in the University of Leeds.
1905. §Brakhan, A. Clare Bank, The Common, Sevenoaks.
1906. §Branfield, Wilfrid. 4 Victoria-villas, Upperthorpe, Sheffield.
1885. *Bratby, William, J.P. Alton Lodge, Lancaster Park, Harrogate.
1905 ‡Brausewetter, Miss. Roedean School, near Brighton.
1909. §Bremner, Alexander. 38 New Broad-street, E.C.
1905. ‡Bremner, R. S. Westminster-chambers, Dale-street, Liverpool.
1905. ‡Bremner, Stanley. Westminster-chambers, Dale-street, Liverpool.

Year of Election

1902. *Brereton, Cloudesley. Briningham House, Briningham, S.O., Norfolk.
1882. **Bretherton, C. E.* 26 *Palace-mansions, Addison Bridge, W.*
1909. *Breton, Miss Adela C. Care of Wilts and Dorset Bank, Bath.
1905. §Brewis, E. 27 Winchelsea-road, Tottenham, N.
1908. §Brickwood, Sir John. Branksmere, Southsea.
1907. *Bridge, Henry Hamilton. Fairfield House, Droxford, Hants.
1904. *Briggs, William, M.A., LL.D., F.R.A.S. Burlington House, Cambridge.
1909. §Briggs, Mrs. Owlbrigg, Cambridge.
1905. ‡Brill, J., Litt.D. Grey College, Bloemfontein, South Africa.
1908. ‡Brindley, H. H. 4 Devana-terrace, Cambridge.
1893. ‡Briscoe, Albert E., B.Sc., A.R.C.Sc. The Hoppet, Little Baddow, Chelmsford.
1904. ‡Briscoe, J. J. Bourn Hall, Bourn, Cambridge.
1905. §Briscoe, Miss. Bourn Hall, Bourn, Cambridge.
1898. ‡BRISTOL, The Right Rev. G. F. BROWNE, D.D., Lord Bishop of. 17 The Avenue, Clifton, Bristol.
1879. *BRITTAIN, W. H., J.P., F.R.G.S. Storth Oaks, Sheffield.
1905. *Broadwood, Brigadier-General R. G. The Deodars, Bloemfontein, South Africa.
1905. ‡Brock, Dr. B. G. P.O. Box 216, Germiston, Transvaal.
1907. ‡Brockington, W. A., M.A. Leicestershire County Council, 38 Bowling Green-street, Leicester.
1896. *Brocklehurst, S. Olinda, Sefton Park, Liverpool.
1901. ‡Brodie, T. G., M.D., F.R.S., Professor of Physiology in the University of Toronto. The University, Toronto, Canada.
1883. *Brodie-Hall, Miss W. L. 5 Devonshire-place, Eastbourne.
1905. ‡Brodigan, C. B. Brakpan Mines, Johannesburg.
1903. ‡BRODRICK, HAROLD, M.A., F.G.S. (Local Sec. 1903.) 7 Aughton-road, Birkdale, Southport.
1904. ‡Bromwich, T. J. I'A., M.A., F.R.S., Professor of Mathematics in Queen's College, Galway.
1906. ‡Brook, Stanley. 18 St. George's-place, York.
1911. §Brooke, Colonel Charles, K., F.R.G.S. Army and Navy Club, Pall Mall, S.W.
1906. *Brooks, F. T. 102 Mawson-road, Cambridge.
1883. **Brotherton, E. A.* 16 *St. James's-place, S.W.*
1883. *Brough, Mrs. Charles S. 27 Salisbury-road, Southsea.
1886. ‡Brough, Joseph, LL.D., Professor of Logic and Philosophy in University College, Aberystwyth.
1905. ‡Brown, A. R. Trinity College, Cambridge.
1863. *BROWN, ALEXANDER CRUM, M.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1874; Local Sec. 1871.) 8 Belgrave-crescent, Edinburgh.
1883. ‡Brown, Mrs. Ellen F. Campbell. 27 Abercromby-square, Liverpool.
1905. §Brown, Professor Ernest William, M.A., D.Sc., F.R.S. Yale University, New Haven, Conn., U.S.A.
1903. ‡Brown, F. W. 6 Rawlinson-road, Southport.
1870. §BROWN, HORACE T., LL.D., F.R.S., F.G.S. (Pres. B, 1899; Council, 1904–11.) 52 Nevern-square, S.W.
1905. ‡Brown, J. Ellis. Durban, Natal.
1881. *Brown, John, M.D. 2 Glebe-terrace, Rondebosch, Cape Colony.
1895. *Brown, John Charles. 39 Burlington-road, Sherwood, Nottingham.
1905. ‡Brown, L. Clifford. Beyer's Kloof, Klapmuts, Cape Colony.

Year of Election

1882. *Brown, Mrs. Mary. 2 Glebe-terrace, Rondebosch, Cape Colony.

1898. §Brown, Nicol, F.G.S. 4 The Grove, Highgate, N.

1905. ‡Brown, R. C. Strathyre, Troyville, Transvaal.

1901. ‡Brown, Professor R. N. Rudmose, D.Sc. The University, Sheffield.

1908. §Brown, Sidney G. 52 Kensington Park-road, W.

1905. §Brown, Mrs. Sidney G. 52 Kensington Park-road, W.

1910. *Brown, Sidney J. R. 52 Kensington Park-road, W.

1884. ‡Brown, W. G. University of Missouri, Columbia, Missouri, U.S.A.

1908. ‡Brown, William, B.Sc. 48 Dartmouth-square, Dublin.

1911. §Brown, Dr. William. Thornfield, Horley, Surrey.

1906. ‡Browne, Charles E., B.Sc. Christ's Hospital, West Horsham.

1909. *Browne, Frank Balfour, M.A., F.R.S.E., F.Z.S. Claremont, Holywood, Co. Down.

1908. ‡Browne, Rev. Henry, M.A. University College, Dublin.

1895. *Browne, H. T. Doughty. 6 Kensington House, Kensington-court, W.

1879. ‡BROWNE, Sir J. CRICHTON, M.D., LL.D., F.R.S., F.R.S.E. 61 Carlisle-place-mansions, Victoria-street, S.W.

1905. *Browne, James Stark, F.R.A.S. The Red House, Mount-avenue, Ealing, W.

1883. ‡Browning, Oscar, M.A. King's College, Cambridge.

1905. §BRUCE, Colonel Sir DAVID, C.B., F.R.S., A.M.S. (Pres. I, 1905). Royal Society Commission, Kasu Hill (near Mvera), Central Angoniland, Nyasaland Protectorate, British Central Africa.

1905. ‡Bruce, Lady. 38 Artillery-mansions, Victoria-street, S.W.

1893. ‡Bruce, William S., LL.D., F.R.S.E. Antarctica, Joppa, Edinburgh.

1902. ‡Bruce-Kingsmill, Major J., F.C.S. 4, St. Ann's-square, Manchester.

1900. *Brumm, Charles. Lismara, Grosvenor-road, Birkdale, Southport.

1896. *Brunner, Right Hon. Sir J. T., Bart. Druid's Cross, Wavertree, Liverpool.

1868. ‡BRUNTON, Sir T. LAUDER, Bart., M.D., D.Sc., F.R.S. (Council, 1908- .) 10 Stratford-place, Cavendish-square, W.

1897. *Brush, Charles F. Cleveland, Ohio, U.S.A.

1886. *BRYAN, G. H., D.Sc., F.R.S., Professor of Mathematics in University College, Bangor.

1894. ‡Bryan, Mrs. R. P. Plas Gwyn, Bangor.

1910. §Bryant, Miss Ella M. 73 St. John's-road, Wembley, Middlesex.

1884. *BRYCE, Rev. Professor GEORGE, D.D., LL.D. Kilmadock, Winnipeg, Canada.

1909. ‡Bryce, Thomas H., M.D., Professor of Anatomy in the University of Glasgow. 2 The College, Glasgow.

1902. *Bubb, Miss E. Maude. Ullenwood, near Cheltenham.

1890. §Bubb, Henry. Ullenwood, near Cheltenham.

1902. *Buchanan, Miss Florence, D.Sc. University Museum, Oxford.

1905. §Buchanan, Hon. Sir John. Clareinch, Claremont, Cape Town.

1881. *Buchanan, John H., M.D. Sowerby, Thirsk.

1871. ‡BUCHANAN, JOHN YOUNG, M.A., F.R.S., F.R.S.E., F.R.G.S., F.C.S. Christ's College, Cambridge.

1909. ‡Buchanan, W. W. P.O. Box 1658, Winnipeg, Canada.

1884. *Buckmaster, Charles Alexander, M.A., F.C.S. 16 Heathfield-road, Mill Hill Park, W.

1904. ‡Buckwell, J. C. North Gate House, Pavilion, Brighton.

1893. §BULLEID, ARTHUR, F.S.A. Dymboro, Midsomer Norton, Bath.

1903. *Bullen, Rev. R. Ashington, F.L.S., F.G.S. Hilden Manor, Tonbridge, Kent.

1909 ‡BULYEA, The Hon. G. H. V. Edmonton, Alberta, Canada.

Year of Election.

1905. ‡Burbury, Mrs. A. A. 15 Melbury-road, W.
1905. ‡Burbury, Miss A. D. 15 Melbury road, W.
1907. ‡Burch, George J., M.A., D.Sc., F.R.S. 28 Norham-road, Oxford.
1881. ‡Burdett-Coutts, William Lehmann, M.P. 1 Stratton-street, Piccadilly, W.
1905. ‡Burdon, E. R., M.A. Ikenhilde, Royston, Herts.
1894. †BURKE, JOHN B. B. Trinity College, Cambridge.
1884. *Burland, Lieut.-Colonel Jeffrey H. 342 Sherbrooke-street West, Montreal, Canada.
1899. ‡Burls, H. T., F.G.S. 2 Verulam-buildings, Gray's Inn, W.C.
1905. ‡Burmeister, H. A. P. 78 Hout-street, Cape Town.
1904. ‡Burn, R. H. 21 Stanley-crescent, Notting-hill, W.
1885. *Burnett, W. Kendall, M.A. Migvie House, North Silver-street, Aberdeen.
1909. ‡Burns, F. D. 203 Morley-avenue, Winnipeg, Canada.
1908. ‡Burnside, W. Snow, D.Sc., Professor of Mathematics in the University of Dublin. 35 Raglan-road, Dublin.
1905. ‡Burroughes, James S., F.R.G.S. The Homestead, Seaford, Sussex.
1909. †Burrows, Theodore Arthur. 187 Kennedy-street, Winnipeg, Canada.
1910. §Burt, Cyril. The University, Liverpool.
1894. ‡Burton, C. V. Boar's Hill, Oxford.
1909. ‡Burton, E. F. 129 Howland-avenue, Toronto, Canada.
1866. *BURTON, FREDERICK M., F.L.S., F.G.S. Highfield, Gainsborough.
1911. §Burton, J. H. County Education Office, Weston-super-Mare.
1892. ‡Burton-Brown, Colonel Alexander, R.A., F.R.A.S., F.G.S. 11 Union-crescent, Margate.
1904. ‡Burtt, Arthur H., D.Sc. 4 South View, Holgate, York.
1906. ‡Burtt, Philip. Swarthmore, St. George's-place, York.
1909. ‡Burwash, E. M., M.A. New Westminster, British Columbia, Canada.
1887. *Bury, Henry. Mayfield House, Farnham, Surrey.
1899. ‡Bush, Anthony. 43 Portland-road, Nottingham.
1895. ‡Bushe, Colonel C. K., F.G.S. 19 Cromwell-road, S.W.
1906. §Bushell, H. A. Melton House, Holgate Hill, York.
1908. *Bushell, W. F. The Hermitage, Harrow.
1910. §Butcher, Miss. 25 Earl's Court-square, S.W.
1884. *Butcher, William Deane, M.R.C.S.Eng. Holyrood, 5 Cleveland-road, Ealing, W.
1884. *Butterworth, W. Oceola, 9 Knowles-road, St. Anne's-on-the-Sea, Lancashire.
1887. *Buxton, J. H. Clumber Cottage, Montague-road, Felixstowe.
1899. ‡Byles, Arthur R. 'Bradford Observer,' Bradford, Yorkshire.

1908. ‡Cadic, Edouard, D.Litt. Mon Caprice, Pembroke Park, Dublin.
1861. *Caird, James Key, LL.D. 8 Roseangle, Dundee.
1905. ‡Calderwood, J. M. P.O. Box 2295, Johannesburg.
1901. ‡Caldwell, Hugh. Blackwood, Newport, Monmouthshire.
1907. ‡Caldwell, K. S. St. Bartholomew's Hospital, S.E.
1908. §Caldwell, Colonel R. T., M.A., LL.M., LL.D., Master of Corpus Christi College, Cambridge.
1897. ‡CALLENDAR, HUGH L., M.A., LL.D., F.R.S. (Council, 1900-06), Professor of Physics in the Imperial College of Science, S.W.
1911. §Calman, W. T., D.Sc. British Museum (Natural History), Cromwell-road, S.W.

Year of Election.

1911. §Cameron, Alexander T. Physiological Department, University of Manitoba, Winnipeg.

1857. ‡CAMERON, Sir CHARLES A., C.B., M.D. 51 Pembroke-road, Dublin.

1909. ‡Cameron, D. C. 65 Roslyn-road, Winnipeg, Canada.

1896. §Cameron, Irving H. 307 Sherbourne-street, Toronto, Canada.

1909. ‡Cameron, Hon. Mr. Justice J. D. Judges' Chambers, Winnipeg, Canada.

1901. §Campbell, Archibald. Park Lodge, Albert-drive, Pollokshields, Glasgow.

1897. ‡Campbell, Colonel J. C. L. Achalader, Blairgowrie, N.B.

1909. *Campbell, R. J. Rideau Hall, 85 Kennedy-street, Winnipeg, Canada.

1909. ‡Campbell, Mrs. R. J. Rideau Hall, 85 Kennedy-street, Winnipeg, Canada.

1902. ‡Campbell, Robert. 21 Great Victoria-street, Belfast.

1890. ‡CANNAN, Professor EDWIN, M.A., LL.D., F.S.S. (Pres. F, 1902.) 11 Chadlington-road, Oxford.

1905. ‡Cannan, Gilbert. King's College, Cambridge.

1897. §Cannon, Herbert. Alconbury, Bexley Heath, Kent.

1905. ‡Cape Town, The Archbishop of. Bishop's-court, Claremont, Cape Colony.

1904. ‡Capell, Rev. G. M. Passenham Rectory, Stony Stratford.

1911. §Capon, R. S. 49A Rodney-street, Liverpool.

1905. *Caporn, Dr. A. W. Roeland-street Baths, Cape Town.

1894. ‡CAPPER, D. S., M.A., Professor of Mechanical Engineering in King's College, W.C.

1887. ‡CAPSTICK, J. W. Trinity College, Cambridge.

1896. *Carden, H. Vandoleur. Fir Lodge, Broomfield, Chelmsford.

1902. ‡Carpenter, G. H., B.Sc., Professor of Zoology in the Royal College of Science, Dublin.

1906. *Carpenter, H. C. H. 11 Oak-road, Withington, Manchester.

1905. §Carpmael, Edward, F.R.A.S., M.Inst.C.E. 24 Southampton-buildings, Chancery-lane, W.C.

1906. *Carr, Richard E. Sylvan Mount, Sylvan-road, Upper Norwood, S.E.

1893. ‡CARR, J. WESLEY, M.A., F.L.S., F.G.S., Professor of Biology in University College, Nottingham.

1889. ‡Carr-Ellison, John Ralph. Hedgeley, Alnwick.

1905. ‡Carrick, Dr. P.O. Box 646, Johannesburg.

1911. §Carruthers, R. G., F.G.S. Geological Survey Office, 33 George-square, Edinburgh.

1867. ‡CARRUTHERS, WILLIAM, F.R.S., F.L.S., F.G.S. (Pres. D, 1886.) 44 Central-hill, Norwood, S.E.

1886. ‡CARSLAKE, J. BARHAM. (Local Sec. 1886.) 30 Westfield-road, Birmingham.

1899. ‡Carslaw, H. S., D.Sc., Professor of Mathematics in the University of Sydney, N.S.W.

1911. §Carter, Godfrey, M.B. 4 Lawson-road, Broomhill, Sheffield.

1900. *Carter, W. Lower, M.A., F.G.S. Bolbec, Grange Road, Watford.

1896. ‡Cartwright, Miss Edith G. 21 York Street-chambers, Bryanston-square, W.

1878. *Cartwright, Ernest H., M.A., M.D. Myskyns, Ticehurst, Sussex.

1870. §Cartwright, Joshua, M.Inst.C.E., F.S.I. 21 Parsons-lane, Bury, Lancashire.

1862. ‡Carulla, F. J. R. 84 Rosehill-street, Derby.

Year of Election.

1894. ‡Carus, Dr. Paul. La Salle, Illinois, U.S.A.
1901. ‡Carver, Thomas A. B., D.Sc., Assoc.M.Inst.C.E. 118 Napiershall-street, Glasgow.
1897. *Case, Willard E. Auburn, New York, U.S.A.
1873. *Cash, William, F.G.S. 26 Mayfield-terrace South, Halifax.
1908. *Cave, Charles J. P., M.A. Ditcham Park, Petersfield.
1910. §Chadburn, A. W. Brincliffe Rise, Sheffield.
1905. *Challenor, Bromley, M.A. The Firs, Abingdon.
1905. *Challenor, Miss E. M. The Firs, Abingdon.
1910. §Chalmers, St. Stephen D. 25 Cornwall-road, Stroud Green, N.
1905. ‡Chamberlain, Miss H. H. Ingleneuk, Upper St. John's-road, Sea Point, Cape Colony.
1901. §Chamen, W. A. South Wales Electrical Power Distribution Company, Royal-chambers, Queen-street, Cardiff.
1905. ‡Champion, G. A. Haraldene, Chelmsford-road, Durban, Natal.
1881. *Champney, John E. 27 Hans-place, S.W.
1908. ‡Chance, Sir Arthur, M.D. 90 Merrion-square, Dublin.
1888. ‡Chandler, S. Whitty, B.A. Bournemouth.
1907. *Chapman, Alfred Chaston, F.I.C. 8 Duke-street, Aldgate, E.C.
1902. *Chapman, D. L. Jesus College, Oxford.
1910. §Chapman, J. E. Kinross.
1899. §CHAPMAN, Professor SYDNEY JOHN, M.A., M.Com. (Pres. F, 1909.) Burnage Lodge, Levenshulme, Manchester.
1910. ‡Chappell, Cyril. 73 Neill-road, Sheffield.
1905. ‡Chassigneux, E. 12 Tavistock-road, Westbourne-park, W.
1904. *Chattaway, F. D., M.A., D.Sc., Ph.D., F.R.S. 103 Woodstock-road, Oxford.
1886. *CHATTOCK, A. P. Heathfield Cottage, Crowcombe, Somerset.
1904. *Chaundy, Theodore William, B.A. 49 Broad-street, Oxford.
1900. §Cheesman, W. Norwood, J.P., F.L.S. The Crescent, Selby.
1874. *Chermside, Lieut.-General Sir Herbert, R.E., G.C.M.G., C.B. Newstead Abbey, Nottingham.
1908. ‡Cherry, Right Hon. R. R. 92 St. Stephen's Green, Dublin.
1910. ‡Chesney, Miss Lilian M., M.B. 381 Glossop-road, Sheffield.
1879. *Chesterman, W. Belmayne, Sheffield.
1911. §Chick, Miss H., D.Sc. Chestergate, Park-hill, Ealing, W.
1908. ‡Chill, Edwin, M.D. Westleigh, Matlock-road, Ealing, W.
1883. ‡Chinery, Edward F., J.P. Lymington.
1884. ‡Chipman, W. W. L. 957 Dorchester-street, Montreal, Canada.
1894. ‡CHISHOLM, G. G., M.A., B.Sc., F.R.G.S. (Pres. E, 1907.) 12 Hallhead-road, Edinburgh.
1899. §Chitty, Edward. Sonnenberg, Castle-avenue, Dover.
1899. ‡Chitty, Mrs. Edward. Sonnenberg, Castle-avenue, Dover.
1904. ‡Chivers, John, J.P. Histon, Cambridgeshire.
1882. ‡Chorley, George. Midhurst, Sussex.
1909. ‡Chow, H. H., M.D. 263 Broadway, Winnipeg, Canada.
1893. *CHREE, CHARLES, D.Sc., F.R.S. Kew Observatory, Richmond, Surrey.
1900. *Christie, R. J. Duke-street, Toronto, Canada.
1875. *Christopher, George, F.C.S. May Villa, Lucien-road, Tooting Common, S.W.
1905. ‡Chudleigh, C. P.O. Box 743, Johannesburg.
1870. §CHURCH, Sir A. H., K.C.V.O., M.A., F.R.S., F.S.A. Shelsley, Ennerdale-road, Kew.
1903. ‡Clapham, J. H., M.A. King's College, Cambridge.
1901. §Clark, Archibald B., M.A., Professor of Political Economy in the University of Manitoba, Winnipeg, Canada.

Year of Election.

1905. *Clark, Cumberland, F.R.G.S. 29 Chepstow-villas, Bayswater, W.
1907. *Clark, Mrs. Cumberland. 29 Chepstow-villas, Bayswater, W.
1877. *Clark, F. J., J.P., F.L.S. Netherleigh, Street, Somerset.
1902. ‡Clark, G. M. South African Museum, Cape Town.
1908. ‡Clark, James, B.Sc. Newtown School, Waterford, Ireland.
1881. *Clark, J. Edmund, B.A., B.Sc. Asgarth, Riddlesdown-road, Purley, Surrey.
1909. §Clark, J. M., M.A., K.C. 16 King-street West, Toronto, Canada.
1908. §Clark, John R. W. Brothock Bank House, Arbroath, Scotland.
1901. *Clark, Robert M., B.Sc., F.L.S. 27 Albyn-place, Aberdeen.
1907. *Clarke, E. Russell. 11 King's Bench-walk, Temple, E.C.
1902. *CLARKE, Miss LILIAN J., B.Sc., F.L.S. Chartfield Cottage, Brasted Chart, Kent.
1905. ‡Clarke, Rev. W. E. C., M.A. P.O. Box 1144, Pretoria.
1889. *CLAYDEN, A. W., M.A., F.G.S. 5 The Crescent, Mount Radford, Exeter.
1908. *Clayton, Miss Edith M. Brackendene, Horsell, Surrey.
1909. §Cleeves, Frederick, F.Z.S. 23 Lime-street, E.C.
1909. ‡Cleeves, W. B. Public Works Department, Government-buildings, Pretoria.
1861. ‡CLELAND, JOHN, M.D., D.Sc., F.R.S. Drumclog, Crewkerne, Somerset.
1905. §Cleland, Mrs. Drumclog, Crewkerne, Somerset.
1905. §Cleland, J. R. Drumclog, Crewkerne, Somerset.
1902. ‡Clements, Olaf P. Tana, St. Bernard's-road, Olton, Warwick.
1904. §CLERK, DUGALD, F.R.S., M.Inst.C.E. (Pres. G, 1908.) 18 Southampton-buildings, W.C.
1909. ‡Cleve, Miss E. K. P. 74 Kensington Gardens-square, W.
1861. *CLIFTON, R. BELLAMY, M.A., F.R.S., F.R.A.S., Professor of Experimental Philosophy in the University of Oxford. 3 Bardwell-road, Banbury-road, Oxford.
1906. §CLOSE, Colonel C. F., R.E., C.M.G., F.R.G.S. (Pres. E, 1911; Council, 1908– .) Army and Navy Club, Pall Mall, S.W.
1883. *CLOWES, FRANK, D.Sc., F.C.S. (Local Sec. 1893.) The Grange, College-road, Dulwich, S.E.
1891. *Coates, Henry, F.R.S.E. Balure, Perth.
1884. ‡Cobb, John. Fitzharris, Abingdon.
1911. §Cobbold, E. S., F.G.S. Church Stretton, Shropshire.
1908. *Cochrane, Miss Constance. The Downs, St. Neots.
1864. *Cochrane, James Henry. Burston House, Pittville, Cheltenham.
1908. ‡Cochrane, Robert, I.S.O., LL.D., F.S.A. 17 Highfield-road, Dublin.
1901. ‡Cockburn, Sir John, K.C.M.G., M.D. 10 Gatestone-road, Upper Norwood, S.E.
1883. ‡Cockshott, J. J. 24 Queen's-road, Southport.
1861. *Coe, Rev. Charles C., F.R.G.S. Whinsbridge, Grosvenor-road, Bournemouth.
1908. ‡Coffey, Denis J., M.B. 2 Arkendale-road, Glenageary, Co. Dublin.
1898. ‡Coffey, George. 5 Harcourt-terrace, Dublin.
1881. *COFFIN, WALTER HARRIS, F.C.S. Passaic, Kew.
1896. *Coghill, Percy de G. 4 Sunnyside, Prince's Park, Liverpool.
1901. §Cohen, N. L. 11 Hyde Park-terrace, W.
1901. *Cohen, R. Waley, B.A. 11 Sussex-square, W.
1909. *Coke, Elmsley, M.Inst.C.E., F.G.S. 26 Low Pavement, Nottingham.
1906. *Coker, Professor Ernest George, M.A., D.Sc., F.R.S.E. City and Guilds of London Technical College, Finsbury, E.C.
1895. *Colby, James George Ernest, M.A., F.R.C.S. Malton, Yorkshire.

Year of
Election.
1895. *Colby, William Henry. Carregwen, Aberystwyth.
1893. §COLE, GRENVILLE A. J., F.G.S., Professor of Geology in the Royal College of Science, Dublin.
1903. ‡Cole, Otto B. 551 Boylston-street, Boston, U.S.A.
1910. §Cole, Thomas Skelton. Westbury, Endcliffe-crescent, Sheffield.
1897. §COLEMAN, Professor A. P., M.A., Ph.D., F.R.S. (Pres. C, 1910.) 476 Huron-street, Toronto, Canada.
1899. ‡Collard, George. The Gables, Canterbury.
1892. ‡Collet, Miss Clara E. 7 Coleridge-road, N.
1887. ‡COLLIE, J. NORMAN, Ph.D., F.R.S., Professor of Organic Chemistry in the University of London. 16 Campden-grove, W.
1893. ‡Collinge, Walter E. The University, Birmingham.
1861. *Collingwood, J. Frederick, F.G.S. 5 Irene-road, Parson's Green, S.W.
1876. ‡COLLINS, J. H., F.G.S. Crinnis House, Par Station, Cornwall.
1865. *Collins, James Tertius. Churchfield, Edgbaston, Birmingham.
1910. *Collins, S. Hoare. 9 Cavendish-place, Newcastle-on-Tyne.
1905. ‡Collins, Rev. Spencer. The Rectory, Victoria West, Cape Colony.
1902. ‡Collins, T. R. Belfast Royal Academy, Belfast.
1910. *Colver, Robert, jun. Graham-road, Ranmoor, Sheffield.
1905. *Combs, Rev. Cyril W., M.A. Elverton, Castle-road, Newport, Isle of Wight.
1910. *Compton, Robert Harold, B.A. Gonville and Caius College, Cambridge.
1871. *Connor, Charles C. 10 College-gardens, Belfast.
1902. ‡Conway, A. W. 100 Leinster-road, Rathmines, Dublin.
1903. ‡Conway, R. Seymour, Litt.D., Professor of Latin in Owens College, Manchester.
1898. §Cook, Ernest H., D.Sc. 27 Berkeley-square, Clifton, Bristol.
1876. *COOKE, CONRAD W. The Pines, Langland-gardens, Hampstead, N.W.
1888. ‡Cooley, George Parkin. Constitutional Club, Nottingham.
1899. *Coomaraswamy, A. K., D.Sc., F.L.S., F.G.S. Broad Campden, Gloucestershire.
1902. *Coomaraswamy, Mrs. A. K. Broad Campden, Gloucestershire.
1903. §Cooper, Miss A. J. 22 St. John-street, Oxford.
1901. *Cooper, C. Forster, B.A. Trinity College, Cambridge.
1907. ‡Cooper, William. Education Offices, Becket-street, Derby.
1911. §Cooper, W. E. Henwick Lodge, Worcester.
1904. *COPEMAN, S. MONCKTON, M.D., F.R.S. Local Government Board, Whitehall, S.W.
1909. §Copland, Mrs. A. J. Gleniffer, 50 Woodberry Down, N.
1904. *Copland, Miss Louisa. 10 Wynnstay-gardens, Kensington, W.
1905. ‡Corben, J. H. Education Department, Klerksdorp, Transvaal.
1909. §Corbett, W. A. 207 Bank of Nova Scotia-building, Winnipeg, Canada.
1887. *Corcoran, Bryan. 23 Croham Park-avenue, South Croydon.
1894. §Corcoran, Miss Jessie R. Rotherfield Cottage, Bexhill-on-Sea.
1911. §Corke, J. H. 101 Victoria-road North, Southsea.
1901. *Cormack, Professor J. D., D.Sc. University College, Gower-street, W.C.
1893. *Corner, Samuel, B.A., B.Sc. Abbotsford House, Waverley-street, Nottingham.
1889. ‡CORNISH, VAUGHAN, D.Sc., F.R.G.S. 31 Kensington Gardens-square, W.
1905. ‡Cornish-Bowden, A. H. Surveyor-General's Office, Cape Town.
1884. *Cornwallis, F. S. W., F.L.S. Linton Park, Maidstone.
1900. §Cortie, Rev. A. L., S.J., F.R.A.S. Stonyhurst College, Blackburn.
1905. ‡Cory, Professor G. E., M.A. Rhodes University College, Grahamstown, Cape Colony.

Year of Election.

1909. *Cossar, G. C., M.A., F.G.S. Southview, Murrayfield, Edinburgh.
1910. §Cossar, James. 53 Belford-road, Edinburgh.
1911. §Cossey, Miss, M.A. High School for Girls, Kent-road, Southsea.
1908. *Costello, John Francis, B.A. The Rectory, Ballymackey, Nenagh, Ireland.
1906. ‡Cotsworth, Moses B. Acomb, York.
1906. ‡*Cotter, J. R. 21 Mayfield-road, Terenure Park, Dublin.*
1874. *COTTERILL, J. H., M.A., F.R.S. Boleskine, Branksome Park, Bournemouth.
1908. ‡Cotton, Alderman W. F., D.L., J.P. Hollywood, Co. Dublin.
1905. ‡Cottrill, G. St. John. P.O. Box 4829, Johannesburg.
1908. ‡Courtenay, Colonel Arthur H., C.B., D.L. United Service Club, Dublin.
1896. ‡COURTNEY, Right Hon. Lord. (Pres. F, 1896.) 15 Cheyne-walk, Chelsea, S.W.
1905. ‡Cousens, R. L. P.O. Box 4261, Johannesburg.
1911. §Couzens, Sir G. E., K.L.H. Glenthorne, Kingston-crescent, Portsmouth.
1908. ‡Cowan, P. C., B.Sc., M.Inst.C.E. 33 Ailesbury-road, Dublin.
1872. *Cowan, Thomas William, F.L.S., F.G.S. Upcott House, Taunton, Somersetshire.
1903. ‡Coward, H. Knowle Board School, Bristol.
1900. §Cowburn, Henry. Dingle Head, Leigh, Lancashire.
1905. ‡Cowell, John Ray. P.O. Box 2141, Johannesburg.
1895. *COWELL, PHILIP H., M.A., D.Sc., F.R.S. 62 Shooters Hill-road, Blackheath, S.E.
1899. ‡Cowper-Coles, Sherard, Assoc.M.Inst.C.E. 82 Victoria-street, S.W.
1867. *Cox, Edward. Cardean, Meigle, N.B.
1909. ‡Cox, F. J. C. Anderson-avenue, Winnipeg, Canada.
1906. §Cox, S. Herbert, Professor of Mining in the Imperial College of Science and Technology, S.W.
1905. ‡Cox, W. H. Royal Observatory, Cape Town.
1908. ‡Craig, James, M.D. 18 Merrion-square North, Dublin.
1911. §Craig, J. I. Homelands, Park-avenue, Worthing.
1884. §CRAIGIE, Major P. G., C.B., F.S.S. (Pres. F, 1900; Council, 1908- .) Brontë House, Lympstone, Devon.
1906. ‡Craik, Sir Henry, K.C.B., LL.D., M.P. 5A Dean's-yard, Westminster, S.W.
1908. *Cramer, W., Ph.D., D.Sc. Physiological Department, The University, Edinburgh.
1906. ‡Cramp, William. Redthorn, Whalley-road, Manchester.
1905. *Cranswick, Wm. Francoys. 34 Boshof-road, Kimberley.
1906. ‡CRAVEN, HENRY. (Local Sec. 1906.) Clifton Green, York.
1905. ‡Crawford, Mrs. A. M. Marchmont, Rosebank, near Cape Town.
1910. *Crawford, O. G. S. The Grove, East Woodhay, Newbury.
1905. ‡Crawford, Professor Lawrence, M.A., D.Sc., F.R.S.E. South African College, Cape Town.
1871. *Crawford, William Caldwell, M.A. 1 Lockharton-gardens, Colinton-road, Edinburgh.
1905. ‡Crawford, W. C., jun. 1 Lockharton-gardens, Colinton-road, Edinburgh.
1871. *CRAWFORD AND BALCARRES, The Right Hon. the Earl of, K.T., LL.D., F.R.S., F.R.A.S. 2 Cavendish-square, W.; and Haigh Hall, Wigan.
1890. §Crawshaw, Charles B. Rufford Lodge, Dewsbury.
1883. *Crawshaw, Edward, F.R.G.S. 25 Tollington-park, N.

Year of Election.
1885. §CREAK, Captain E. W., C.B., R.N., F.R.S. (Pres. E, 1903; Council, 1896–1903.) 9 Hervey-road, Blackheath, S.E.
1876. *Crewdson, Rev. Canon George. Whitstrav, Cambridge.
1887. *Crewdson, Theodore. Spurs, Styall, Handforth, Manchester.
1911. §Crick, George C., F.G.S. British Museum (Natural History), S.W.
1904. ‡Crilly, David. 7 Well-street, Paisley.
1880. *Crisp, Sir Frank, B.A., LL.B., F.L.S., F.G.S. 5 Lansdowne-road, Notting Hill, W.
1908. §Crocker, J. Meadmore. Albion House, Bingley, Yorkshire.
1905. §Croft, Miss Mary. 17 Pelham-crescent, S.W.
1890. *Croft, W. B., M.A. Winchester College, Hampshire.
1908. §Crofts, D. G. Cadastral Survey, Nairobi, British East Africa.
1878. *Croke, John O'Byrne, M.A. Clouncagh, Ballingarry-Lacy, Co. Limerick.
1903. *Crompton, Holland. Oaklyn, Cross Oak-road, Berkhamsted.
1901. ‡CROMPTON, Colonel R. E., C.B., M.Inst.C.E. (Pres. G, 1901.) Kensington-court, W.
1887. ‡CROOK, HENRY T., M.Inst.C.E. Lancaster-avenue, Manchester.
1898. §CROOKE, WILLIAM, B.A. (Pres. H, 1910; Council, 1910– .) Langton House, Charlton Kings, Cheltenham.
1865. §CROOKES, Sir WILLIAM, O.M., D.Sc., F.R.S., V.P.C.S. (PRESIDENT, 1898; Pres. B, 1886; Council, 1885–91.) 7 Kensington Park-gardens, W.
1879. ‡Crookes, Lady. 7 Kensington Park-gardens, W.
1897. *CROOKSHANK, E. M., M.B. Ashdown Forest, Forest Row, Sussex.
1909. ‡Crosby, Rev. E. H. Lewis, B.D. 36 Rutland-square, Dublin.
1905. ‡Crosfield, Hugh T. Walden, Coombe-road, Croydon.
1894. *Crosfield, Miss Margaret C. Undercroft, Reigate.
1870. *CROSFIELD, WILLIAM. 3 Fulwood-park, Liverpool.
1904. §Cross, Professor Charles R. Massachusetts Institute of Technology, Boston, U.S.A.
1890. ‡Cross, E. Richard, LL.B. Harwood House, New Parks-crescent, Scarborough.
1905. §Cross, Robert. 13 Moray-place, Edinburgh.
1904. *CROSSLEY, A. W., D.Sc., Ph.D., F.R.S., Professor of Chemistry to the Pharmaceutical Society of Great Britain. 10 Crediton-road, West Hampstead, N.W.
1908. ‡Crossley, F. W. 30 Molesworth-street, Dublin.
1897. *Crosweller, Mrs. W. T. Kent Lodge, Sidcup, Kent.
1890. *Crowley, Ralph Henry, M.D. Sollershott W., Letchworth.
1910. §Crowther, Dr. C., M.A. The University, Leeds.
1910. *Crowther, James Arnold. St. John's College, Cambridge.
1911. §Crush, S. T. Care of Messrs. Yarrow & Co., Ltd., Scotstoun West, Glasgow.
1883. *CULVERWELL, EDWARD P., M.A., Professor of Education in Trinity College, Dublin.
1883. ‡Culverwell, T. J. H. Litfield House, Clifton, Bristol.
1911. §Cumming, Alexander Charles, D.Sc. Chemistry Department, University of Edinburgh.
1911. §Cummins, Major H. A., M.D., C.M.G., Professor of Botany in University College, Cork.
1898. ‡Cundall, J. Tudor. 1 Dean Park-crescent, Edinburgh.
1861. *Cunliffe, Edward Thomas. The Parsonage, Handforth, Manchester.
1861. *Cunliffe, Peter Gibson. Dunedin, Handforth, Manchester.
1905. ‡Cunningham, Miss A. 2 St. Paul's-road, Cambridge.
1882. *CUNNINGHAM, Lieut.-Colonel ALLAN, R.E., A.I.C.E. 20 Essex-villas, Kensington, W.

Year of Election.
1905. ‡Cunningham, Andrew. Earlsferry, Campground-road, Mowbray, South Africa.
1911. §Cunningham, F. St. John's College, Cambridge.
1885. ‡CUNNINGHAM, J. T., B.A. Biological Laboratory, Plymouth.
1869. ‡CUNNINGHAM, ROBERT O., M.D., F.L.S., Professor of Natural History in Queen's College, Belfast.
1883. *CUNNINGHAM, Rev. W., D.D., D.Sc. (Pres. F, 1891, 1905.) Trinity College, Cambridge.
1892. ‡*Cunningham-Craig, E. H., B.A., F.G.S. 14A Dublin-street, Edinburgh.*
1900. *Cunnington, William A., M.A., Ph.D., F.Z.S. 25 Orlando-road, Clapham Common, S.W.
1908. ‡Currelly, C. T., M.A., F.R.G.S. United Empire Club, 117 Piccadilly, W.
1892. *Currie, James, M.A., F.R.S.E. Larkfield, Wardie-road, Edinburgh.
1905. ‡Currie, Dr. O. J. Manor House, Mowbray, Cape Town.
1905. ‡Currie, W. P. P.O. Box 2010, Johannesburg.
1902. ‡Curry, Professor M., M.Inst.C.E. 5 King's-gardens, Hove.
1911. §Curtis, Charles. Field House, Cainscross, Stroud, Gloucestershire.
1883. ‡Cushing, Mrs. M. Rosslynlee, Woodside Green, South Norwood, S.E.
1881. §Cushing, Thomas, F.R.A.S. Rosslynlee, Woodside Green, South Norwood, S.E.
1907. ‡CUSHNY, ARTHUR R., M.D., F.R.S., Professor of Pharmacology in University College, Gower-street, W.C.

1910. §Dakin, Dr. W. J. The University, Liverpool.
1898. *DALBY, W. E., M.A., B.Sc., M.Inst.C.E. (Pres. G, 1910), Professor of Civil and Mechanical Engineering in the City and Guilds of London Institute, Exhibition-road, S.W.
1889. *Dale, Miss Elizabeth. Garth Cottage, Oxford-road, Cambridge.
1906. §Dale, William, F.S.A., F.G.S. The Lawn, Archer's-road, Southampton.
1907. ‡DALGLIESH, RICHARD, J.P., D.L. Ashfordby Place, near Melton Mowbray.
1904. *DALTON, J. H. C., M.D. The Plot, Adams-road, Cambridge.
1862. ‡DANBY, T. W., M.A., F.G.S. The Crouch, Seaford, Sussex.
1905. ‡Daniel, Miss A. M. 3 St. John's-terrace, Weston-super-Mare.
1901. ‡Daniell, G. F., B.Sc. Woodberry, Oakleigh Park, N.
1896. §Danson, F. C. Tower-buildings, Water-street, Liverpool.
1849. *Danson, Joseph. Montreal, Canada.
1897. ‡*Darbishire, F. V., B.A., Ph.D. South-Eastern Agricultural College, Wye, Kent.*
1903. §Darbishire, Dr. Otto V. Armstrong College, Newcastle-on-Tyne.
1904. *Darwin, Charles Galton. Newnham Grange, Cambridge.
1899. *Darwin, Erasmus. The Orchard, Huntingdon-road, Cambridge.
1882. *DARWIN, FRANCIS, M.A., M.B., LL.D., D.Sc., F.R.S., F.L.S. (PRESIDENT, 1908; Pres. D, 1891; Pres. K, 1904; Council, 1882-84, 1897-1901.) 10 Madingley-road, Cambridge.
1881. *DARWIN, Sir GEORGE HOWARD, K.C.B., M.A., LL.D., F.R.S., F.R.A.S. (PRESIDENT, 1905; Pres. A, 1886; Council, 1886-1892), Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. Newnham Grange, Cambridge.
1905. ‡Darwin, Lady. Newnham Grange, Cambridge.

Year of Election.

1878. *DARWIN, HORACE, M.A., F.R.S. The Orchard, Huntingdon-road, Cambridge.
1894. *DARWIN, Major LEONARD, F.R.G.S. (Pres. E, 1896; Council, 1899–1905.) 12 Egerton-place, South Kensington, S.W.
1882. †Darwin, W. E., B.A., F.G.S. 11 Egerton-place, S.W.
1910. §Dauncey, Mrs. Thursby. Lady Stewert, Heath-road, Weybridge.
1908. ‡Davey, H. 15 Victoria-road, Brighton.
1880. *DAVEY, HENRY, M.Inst.C.E. Conaways, Ewell, Surrey.
1884. ‡David, A. J., B.A., LL.B. 4 Harcourt-buildings, Temple, E.C.
1904. §Davidge, H. T., B.Sc., Professor of Electricity in the Ordnance College, Woolwich.
1909. ‡Davidson, A. R. 150 Stradbrooke-place, Winnipeg, Canada.
1902. *Davidson, S. C. Seacourt, Bangor, Co. Down.
1910. *Davie, Robert C., M.A., B.Sc. 16 Ruthven-street, Kelvinside, Glasgow.
1887. *Davies, H. Rees. Treborth, Bangor, North Wales.
1904. §Davies, Henry N., F.G.S. St. Chad's, Weston-super-Mare.
1906. ‡Davies, S. H. Ryecroft, New Earswick, York.
1893. *Davies, Rev. T. Witton, B.A., Ph.D., D.D., Professor of Semitic Languages in University College, Bangor, North Wales.
1896. *Davies, Thomas Wilberforce, F.G.S. 41 Park-place, Cardiff.
1870. *Davis, A. S. St. George's School, Roundhay, near Leeds.
1873. *Davis, Alfred. 37 Ladbroke-grove, W.
1905. ‡Davis, C. R. S. National Bank-buildings, Johannesburg.
1896. *Davis, John Henry Grant. The Hawthorns, Sutton-road, Walsall.
1910. §Davis, John King. 2 Brockenhurst Green-street, Jersey.
1905. §Davis, Luther. P.O. Box 898, Johannesburg.
1885. *Davis, Rev. Rudolf. Mornington, Elmbridge-road, Gloucester.
1905. ‡Davy, Mrs. Alice Burtt. P.O. Box 434, Pretoria.
1905. ‡Davy, Joseph Burtt, F.R.G.S., F.L.S. P.O. Box 434, Pretoria.
1864. ‡DAWKINS, W. BOYD, D.Sc., F.R.S., F.S.A., F.G.S. (Pres. C, 1888; Council, 1882–88.) Fallowfield House, Fallowfield, Manchester.
1885. *Dawson, Lieut.-Colonel H. P., R.A. Hartlington Hall, Burnsall, Skipton-in-Craven.
1901. *Dawson, P. The Acre, Maryhill, Glasgow.
1905. ‡Dawson, Mrs. The Acre, Maryhill, Glasgow.
1884. ‡DAWSON, SAMUEL (Local Sec. 1884.) 258 University-street, Montreal, Canada.
1906. §Dawson, William Clarke. 16 Parliament-street, Hull.
1859. *Dawson, Captain W. G. Abbots Morton, near Worcester.
1909. ‡Day, Miss M. Edith. 290 Portage-avenue, Winnipeg, Canada.
1900. ‡Deacon, M. Whittington House, near Chesterfield.
1909. §Dean, George, F.R.G.S. 5 Wordsworth-mansions, Queen's Club-gardens, W.
1901. *Deasy, Captain H. H. P. 24 Evelyn-gardens, S.W.
1884. *Debenham, Frank, F.S.S. 1 Fitzjohn's-avenue, N.W.
1866. ‡DEBUS, HEINRICH, Ph.D., F.R.S., F.C.S. (Pres. B, 1869; Council, 1870–75.) 4 Schlangenweg, Cassel, Hessen.
1893. *Deeley, R. M., M.Inst.C.E., F.G.S. Inglewood, Longcroft-avenue, Harpenden, Herts.
1911. §Delahunt, C. G. The Municipal College, Portsmouth.
1878. ‡DELANY, Very Rev. WILLIAM, LL.D. University College, Dublin.
1908. *Delf, Miss E. M. Westfield College, Hampstead, N.W.
1907. ‡De Lisle, Mrs. Edwin. Charnwood Lodge, Coalville, Leicestershire.
1896. ‡Dempster, John. Tynron, Noctorum, Birkenhead.
1902. *DENDY, ARTHUR, D.Sc., F.R.S., F.L.S., Professor of Zoology in King's College, London, W.C.

Year of Election.

1908. ‡Dennehy, W. F. 23 Leeson-park, Dublin.

1889. §DENNY, ALFRED, M.Sc., F.L.S., Professor of Biology in the University of Sheffield.

1905. ‡Denny, G. A. 603-4 Consolidated-buildings, Fox-street, Johannesburg.

1909. §Dent, Edward, M.A. 2 Carlos-place, W.

1874. *Derham, Walter, M.A., LL.M., F.G.S. Junior Carlton Club, Pall Mall, S.W.

1907. *Desch, Cecil H., D.Sc., Ph.D. 9 Spring-gardens, North Kelvinside, Glasgow.

1908. §Despard, Miss Kathleen M. 6 Sutton Court-mansions, Grove Park-terrace, Chiswick, W.

1894. *Deverell, F. H. 7 Grote's-place, Blackheath, S.E.

1868. *DEWAR, Sir JAMES, M.A., LL.D., D.Sc., F.R.S., F.R.S.E., V.P.C.S., Fullerian Professor of Chemistry in the Royal Institution, London, and Jacksonian Professor of Natural and Experimental Philosophy in the University of Cambridge. (PRESIDENT, 1902; Pres. B, 1879; Council, 1883-88.) 1 Scroope-terrace, Cambridge.

1881. ‡Dewar, Lady. 1 Scroope-terrace, Cambridge.

1884. *Dewar, William, M.A. Horton House, Rugby.

1905. ‡*Dewhirst, Miss May. Pembroke House, Oxford-road, Colchester.*

1901. ‡Dick, George Handasyde. 31 Hamilton-drive, Hillhead, Glasgow.

1908. §Dicks, Henry. Haslecourt, Horsell, Woking.

1904. ‡Dickson, Right Hon. Charles Scott, K.C., LL.D., M.P. Carlton Club, Pall Mall, S.W.

1881. ‡Dickson, Edmund, M.A., F.G.S. Claughton House, Garstang, R.S.O., Lancashire.

1887. §DICKSON, H. N., D.Sc., F.R.S.E., F.R.G.S. The Lawn, Upper Redlands-road, Reading.

1902. §Dickson, James D. Hamilton, M.A., F.R.S.E. 6 Cranmer-road, Cambridge.

1877. ‡Dillon, James, M.Inst.C.E. 36 Dawson-street, Dublin.

1908. ‡Dines, J. S. Pyrton Hill, Watlington.

1901. §Dines, W. H., B.A., F.R.S. Pyrton Hill, Watlington.

1900. §DIVERS, Professor EDWARD, M.D., D.Sc., F.R.S. (Pres. B, 1902.) 3 Canning-place, Palace Gate, W.

1898. *Dix, John William S. Hampton Lodge, Durdham Down, Clifton, Bristol.

1905. §Dixey, F. A., M.A., M.D., F.R.S. Wadham College, Oxford.

1899. *DIXON, A. C., D.Sc., F.R.S., Professor of Mathematics in Queen's University, Belfast. Hurstwood, Malone Park, Belfast.

1874. *DIXON, A. E., M.D., Professor of Chemistry in University College, Cork.

1900. ‡Dixon, A. Francis, Sc.D., Professor of Anatomy in the University of Dublin.

1905. ‡Dixon, Miss E. K. Fern Bank, St. Bees, Cumberland.

1908. ‡Dixon, Edward K., M.E., M.Inst.C.E. Castlebar, Co. Mayo.

1888. ‡Dixon, Edward T. Racketts, Hythe, Hampshire.

1908. *DIXON, ERNEST, B.Sc., F.G.S. The Museum, Jermyn-street, S.W.

1900. *Dixon, Lieut.-Colonel George, M.A. Fern Bank, St. Bees, Cumberland.

1879. *DIXON, HAROLD B., M.A., F.R.S., F.C.S. (Pres. B, 1894), Professor of Chemistry in the Victoria University, Manchester.

1902. ‡Dixon, Henry H., D.Sc., F.R.S., Professor of Botany in the University of Dublin. Clevedon, Temple-road, Dublin.

1908. *Dixon, Walter, F.R.M.S. Derwent, 30 Kelvinside-gardens, Glasgow.

Year of Election.

1907. *Dixon, Professor Walter E., F.R.S. The Museums, Cambridge.
1902. ‡Dixon, W. V. Scotch Quarter, Carrickfergus.
1896. §Dixon-Nuttall, F. R. Ingleholme, Eccleston Park, Prescot.
1890. ‡Dobbie, James J., D.Sc., LL.D., F.R.S., Principal of the Government Laboratories, 13 Clement's Inn-passage, W.C.
1885. §Dobbin, Leonard, Ph.D. The University, Edinburgh.
1860. *Dobbs, Archibald Edward, M.A. Castle Dobbs, Carrickfergus, Co. Antrim.
1902. ‡Dobbs, F. W. 2 Willowbrook, Eton, Windsor.
1905. ‡Dobson, Professor J. H. Transvaal Technical Institute, Johannesburg.
1908. ‡Dodd, Hon. Mr. Justice. 26 Fitzwilliam-square, Dublin.
1876. ‡Dodds, J. M. St. Peter's College, Cambridge.
1905. ‡Dodds, Dr. W. J. Valkenberg, Mowbray, Cape Colony.
1904. ‡Doncaster, Leonard, M.A. King's College, Cambridge.
1896. ‡Donnan, F. E. Ardenmore-terrace, Holywood, Ireland.
1901. ‡Donnan, F. G., M.A., Ph.D., F.R.S., Professor of Physical Chemistry. The University, Liverpool.
1905. ‡Donnan, H. Allandale, Claremont, Cape Colony.
1905. ‡Donner, Arthur. Helsingfors, Finland.
1905. §Dornan, Rev. S. S. P.O. Box 510, Bulawayo, South Rhodesia, South Africa.
1863. *Doughty, Charles Montagu. 26 Grange-road, Eastbourne.
1909. ‡Douglas, A. J., M.D. City Health Department, Winnipeg, Canada.
1909. *Douglas, James. 99 John-street, New York, U.S.A.
1905. ‡Douglas-McMillan, Mrs. A. 31 Ford-street, Jeppestown, Transvaal.
1884. ‡Dove, Miss Frances. Wycombe Abbey School, Buckinghamshire.
1903. ‡Dow, Miss Agnes R. 81 Park-mansions, Knightsbridge, S.W.
1884. *Dowling, D. J. Sycamore, Clive-avenue, Hastings.
1865. *Dowson, E. Theodore, F.R.M.S. Geldeston, near Beccles, Suffolk.
1881. *Dowson, J. Emerson, M.Inst.C.E. 26 Egerton-crescent, S.W.
1892. *Dreghorn, David, J.P. Greenwood, Pollokshields, Glasgow.
1905. ‡Drew, H. W., M.B., M.R.C.S. Mocollup Castle, Ballyduff, S.O., Co. Waterford.
1906. *Drew, Joseph Webster, M.A., LL.M. Fashoda, Scarborough.
1906. *Drew, Mrs. Fashoda, Scarborough.
1908. ‡Droop, J. P. 11 Cleveland-gardens, Hyde Park, W.
1893. §Druce, G. Claridge, M.A., F.L.S. (Local Sec. 1894.) Yardley Lodge, 9 Crick-road, Oxford.
1909. *Drugman, Julien, Ph.D., M.Sc. 117 Rue Gachard, Brussels.
1905. ‡Drury, H. P.O. Box 2305, Johannesburg.
1905. ‡Drury, Mrs. H. P.O. Box 2305, Johannesburg.
1907. ‡Drysdale, Charles V., D.Sc. Northampton Institute, Clerkenwell, E.C.
1892. ‡Du Bois, Professor Dr. H. Herwarthstrasse 4, Berlin, N.W.
1856. *Ducie, The Right Hon. Henry John Reynolds Moreton, Earl of, F.R.S., F.G.S. 16 Portman-square, W.
1870. ‡Duckworth, Henry, F.L.S., F.G.S. 7 Grey Friars, Chester.
1900. *Duckworth, W. L. H., M.D., Sc.D. Jesus College, Cambridge.
1895. *Duddell, William, F.R.S. 47 Hans-place, S.W.
1906. ‡Dudgeon, Gerald C., Superintendent of Agriculture for British West Africa. Bathurst, Gambia, British West Africa.
1904. *Duffield, W. Geoffrey. University College, Reading.
1890. ‡Dufton, S. F. Trinity College, Cambridge.
1911. §Dummer, John. 85 Cottage-grove, Southsea.
1909. ‡Duncan, D. M., M.A. 83 Spence-street, Winnipeg, Canada.
1891. *Duncan, Sir John, J.P. 'South Wales Daily News' Office, Cardiff.

Year of
Election.

1910. ‡Dunn, Rev. J. Road Hill Vicarage, Bath.

1876. ‡Dunnachie, James. 48 West Regent-street, Glasgow.

1884. §Dunnington, Professor F. P. University of Virginia, Charlottesville, Virginia, U.S.A.

1893. *Dunstan, M. J. R., Principal of the South-Eastern Agricultural College, Wye, Kent.

1891. ‡Dunstan, Mrs. South-Eastern Agricultural College, Wye, Kent.

1885. *DUNSTAN, Professor WYNDHAM, M.A., LL.D., F.R.S., V.P.C.S. (Pres. B, 1906; Council, 1905–08), Director of the Imperial Institute, S.W.

1911. §Dupree, Colonel Sir W. T. Craneswater, Southsea.

1905. §Dutton, C. L. O'Brien. High Commissioner's Office, Johannesburg.

1910. §Dutton, F. V., B.Sc. County Agricultural Laboratories, Richmond-road, Exeter.

1895. *DWERRYHOUSE, ARTHUR R., D.Sc., F.G.S. Doraness, Deramore Park, Belfast.

1911. §Dye, Charles. Woodcrofts, London-road, Portsmouth.

1885. *Dyer, Henry, M.A., D.Sc. 8 Highburgh-terrace, Dowanhill, Glasgow.

1895. §Dymond, Thomas S., F.C.S. Savile Club, Piccadilly, W.

1905. *DYSON, F. W., M.A., F.R.S. (Council, 1905–11), Astronomer Royal. Royal Observatory, Greenwich, S.E.

1910. ‡Dyson, W. H. Maltby Colliery, near Rotherham, Yorkshire.

1905. ‡Earp, E. J. P.O. Box 538, Cape Town.

1899. ‡East, W. H. Municipal School of Art, Science, and Technology, Dover.

1909. *Easterbrook, C. C., M.A., M.D. Crichton Royal Institution, Dumfries.

1893. *Ebbs, Alfred B. Northumberland-alley, Fenchurch-street, E.C.

1906. *Ebbs, Mrs. A. B. Tuborg, Durham-avenue, Bromley, Kent.

1909. ‡Eccles, J. R. Gresham's School, Holt, Norfolk.

1903. ‡Eccles, W. H., D.Sc. 37 Chelsea-gardens, Chelsea Bridge-road, S.W.

1908. *Eddington, A. S., M.A., M.Sc. Royal Observatory, Greenwich, S.E.

1870. *Eddison, John Edwin, M.D., M.R.C.S. The Lodge, Adel, Leeds.

1858. *Eddy, James Ray, F.G.S. The Grange, Carleton, Skipton.

1911. *Edge, S. F. 14 New Burlington-street, W.

1911. *Edgell, Miss Beatrice. Bedford College, Baker-street, W.

1884. *Edgell, Rev. R. Arnold, M.A. Beckley Rectory, East Sussex.

1887. §EDGEWORTH, F. Y., M.A., D.C.L., F.S.S. (Pres. F, 1889; Council, 1879–86, 1891–98), Professor of Political Economy in the University of Oxford. All Souls College, Oxford.

1870. *Edmonds, F. B. 6 Clement's Inn, W.C.

1883. ‡Edmonds, William. Wiscombe Park, Colyton, Devon.

1888. *Edmunds, Henry. Antron, 71 Upper Tulse-hill, S.W.

1901. *EDRIDGE-GREEN, F. W., M.D., F.R.C.S. 99 Walm-lane, Willesden Green, N.W.

1899. §Edwards, E. J., Assoc.M.Inst.C.E. 27 West-side, Wandsworth Common, S.W.

1903. ‡Edwards, Mrs. Emily. Norley Grange, 73 Leyland-road, Southport.

1903. ‡Edwards, Francis. Norley Grange, 73 Leyland-road, Southport.

1903. ‡Edwards, Miss Marion K. Norley Grange, 73 Leyland-road, Southport.

1901. ‡Eggar, W. D. Eton College, Windsor.

Year of Election.

1909. ‡Eggertson, Arni. 120 Emily-street, Winnipeg, Canada.
1909. §Ehrenborg, G. B. 518 Winch-building, Vancouver, B.C., Canada.
1907. *Elderton, W. Palin. 74 Mount Nod-road, Streatham, S.W.
1890. §Elford, Percy. 115 Woodstock-road, Oxford.
1901. *Elles, Miss Gertrude L., D.Sc. Newnham College, Cambridge.
1904. ‡Elliot, Miss Agnes I. M. Newnham College, Cambridge.
1904 ‡Elliot, R. H. Clifton Park, Kelso, N.B.
1904 ‡*Elliot, T. R. B. Holme Park, Rotherfield, Sussex.*
1891. ‡Elliott, A. C., D.Sc., M.Inst.C.E., Professor of Engineering in University College, Cardiff. 2 Plasturton-avenue, Cardiff.
1905. ‡Elliott, C. C., M.D. Church-square, Cape Town.
1883. *ELLIOTT, EDWIN BAILEY, M.A., F.R.S., F.R.A.S., Waynflete Professor of Pure Mathematics in the University of Oxford. 4 Bardwell-road, Oxford.
Elliott, John Fogg. Elvet Hill, Durham.
1906. *Ellis, David, D.Sc., Ph.D. Technical College, Glasgow.
1875. *Ellis, H. D. 12 Gloucester-terrace, Hyde Park, W.
1906. §ELLIS, HERBERT. 120 Regent-road, Leicester.
1880. *ELLIS, JOHN HENRY. (Local Sec. 1883.) 10 The Crescent, Plymouth.
1891. §Ellis, Miss M. A. 14 Wellington-square, Oxford.
1906. ‡ELMHIRST, CHARLES E. (Local Sec. 1906.) 29 Mount-vale, York.
1910. §Elmhirst, Richard. Marine Biological Station, Millport.
1911. §Elphinstone, G. K. B. 36 Leicester-square, W.C.
1911. §Elwes, H. J., F.R.S. Colesbourne Park, near Cheltenham.
1884. ‡Emery, Albert H. Stamford, Connecticut, U.S.A.
1911. §Emmett, Dr. R. Winton, London-road, Portsmouth.
1869. *Enys, John Davies. Enys, Penryn, Cornwall.
1862. *ESSON, WILLIAM, M.A., F.R.S., F.R.A.S., Savilian Professor of Geometry in the University of Oxford. 13 Bradmore-road, Oxford.
1887. *Estcourt, Charles, F.I.C. 5 Seymour-grove, Old Trafford, Manchester.
1887. *Estcourt, P. A., F.C.S., F.I.C. 5 Seymour-grove, Old Trafford, Manchester.
1911. ‡ETHERTON, G. HAMMOND. (Local Sec., 1911.) Town Hall, Portsmouth.
1897. *Evans, Lady. Britwell, Berkhamsted, Herts.
1889. *EVANS, A. H., M.A. 9 Harvey-road, Cambridge.
1905. ‡Evans, Mrs. A. H. 9 Harvey-road, Cambridge.
1870. *EVANS, Sir ARTHUR JOHN, M.A., LL.D., F.R.S., F.S.A. (Pres. H, 1896.) Youlbury, Abingdon.
1908. ‡Evans, Rev. Henry, D.D., Commissioner of National Education, Ireland. Blackrock, Co. Dublin.
1887. *Evans, Mrs. Isabel. Hoghton Hall, Hoghton, near Preston.
1883. *Evans, Mrs. James C. Casewell Lodge, Llanwrtyd Wells, South Wales.
1910. *EVANS, JOHN W., D.Sc., LL.B., F.G.S. 75 Craven Park-road, Harlesden, N.W.
1885. *Evans, Percy Bagnall. The Spring, Kenilworth.
1905. ‡Evans, R. O. Ll. Broom Hall, Chwilog, R.S.O., Carnarvonshire.
1905. ‡Evans, T. H. 9 Harvey-road, Cambridge.
1910. ‡Evans, T. J. The University, Sheffield.
1905. ‡Evans, Thomas H. P.O. Box 1276, Johannesburg.
1865. *Evans, William. The Spring, Kenilworth.
1909. ‡EVANS, W. SANFORD, M.A. (Local Sec. 1909.) 43 Edmonton-street, Winnipeg.

Year of
Election.
1903. ‡Evatt, E. J., M.B. 8 Kyveilog-street, Cardiff.
1902. *Everett, Percy W. Oaklands, Elstree, Hertfordshire.
1883. ‡Eves, Miss Florence. Uxbridge.
1881. ‡EWART, J. COSSAR, M.D., F.R.S. (Pres. D, 1901), Professor of Natural History in the University of Edinburgh.
1874. ‡EWART, Sir W. QUARTUS, Bart. (Local Sec. 1874.) Glenmachan, Belfast.
1876. *EWING, Sir JAMES ALFRED, K.C.B., M.A., LL.D., F.R.S., F.R.S.E., M.Inst.C.E. (Pres. G, 1906), Director of Naval Education, Admiralty, S.W. Froghole, Edenbridge, Kent.
1903. §Ewing, Peter, F.L.S. The Frond, Uddingston, Glasgow.
1884. *Eyerman, John, F.Z.S. Oakhurst, Easton, Pennsylvania, U.S.A.
1905. ‡Eyre, Dr. G. G. Claremont, Cape Colony.
Eyton, Charles. Hendred House, Abingdon.

1906. *Faber, George D. 14 Grosvenor-square, W.
1901. *Fairgrieve, M. McCallum. 67 Great King-street, Edinburgh.
1865. *FAIRLEY, THOMAS, F.R.S.E., F.C.S. 8 Newton-grove, Leeds.
1910. §Falconer, J. D. The Limes, Little Berkhamsted, Hertford.
1908. ‡Falconer, Robert A., M.A. 44 Merrion-square, Dublin.
1896. §Falk, Herman John, M.A. Thorshill, West Kirby, Cheshire.
1902. §Fallaize, E. N., B.A. Vinchelez, Chase Court-gardens, Windmill-hill, Enfield.
1907. *Fantham, H. B., D.Sc. New Museums, Cambridge.
1902. §Faren, William. 11 Mount Charles, Belfast.
1892. *FARMER, J. BRETLAND, M.A., F.R.S., F.L.S. (Pres. K, 1907.) Shirley Holms, Gerrards Cross.
1886. ‡Farncombe, Joseph, J.P. Saltwood, Spencer-road, Eastbourne.
1897. *Farnworth, Mrs. Ernest. Broadlands, Goldthorn Hill, Wolverhampton.
1904. ‡Farnworth, Miss Olive. Broadlands, Goldthorn Hill, Wolverhampton.
1885. *Farquharson, Mrs. R. F. O. Tillydrine, Kincardine O'Neil, N.B.
1905. ‡Farrar, Edward. P.O. Box 1242, Johannesburg.
1903. §Faulkner, Joseph M. 17 Great Ducie-street, Strangeways, Manchester.
1890. *Fawcett, F. B. University College, Bristol.
1906. §Fawcett, Henry Hargreave. 20 Margaret-street, Cavendish-square, W.
1900. ‡FAWCETT, J. E., J.P. (Local Sec. 1900.) Low Royd, Apperley Bridge, Bradford.
1902. *Fawsitt, C. E., Ph.D., Professor of Chemistry in the University of Sydney, New South Wales.
1911. *Fay, Mrs. A. Q. Chedworth, Rustat-road, Cambridge.
1909. *Fay, Charles Ryle, M.A. Christ's College, Cambridge.
1906. *Fearnsides, Edwin G., M.A., M.B., B.Sc. London Hospital, E.
1901. *Fearnsides, W. G., M.A., F.G.S. Sidney Sussex College, Cambridge.
1905. §Feilden, Colonel H. W., C.B., F.R.G.S., F.G.S. Burwash, Sussex.
1900. *Fennell, William John. Deramore Drive, Belfast.
1904. ‡Fenton, H. J. H., M.A., F.R.S. 19 Brookside, Cambridge.
1871. *FERGUSON, JOHN, M.A., LL.D., F.R.S.E., F.S.A., F.C.S., Professor of Chemistry in the University of Glasgow.
1896. *Ferguson, Hon. John, C.M.G. Naseby House, Newera Elliya, Ceylon.

Year of Election.

1901. ‡Ferguson, R. W. Municipal Technical School, the Gamble Institute, St. Helens, Lancashire.

1863. *Fernie, John. Box No. 2, Hutchinson, Kansas, U.S.A.

1910. *Ferranti, S. Z. de, M.Inst.C.E. Grindleford, near Sheffield.

1905. *Ferrar, H. T., M.A., F.G.S. Geological Survey of Egypt, Giza, Egypt.

1873. ‡FERRIER, Sir DAVID, M.A., M.D., LL.D., F.R.S., Professor of Neuro-Pathology in King's College, London. 34 Cavendish-square, W.

1909. ‡Fetherstonhaugh, Professor Edward P., B.Sc. 119 Betourney-street, Winnipeg, Canada.

1882. §Fewings, James, B.A., B.Sc. King Edward VI. Grammar School, Southampton.

1897. ‡Field, George Wilton, Ph.D. Room 158, State House, Boston, Massachusetts, U.S.A.

1907. §Fields, Professor J. C. The University, Toronto, Canada.

1906. §FILON, L. N. G., D.Sc., F.R.S. Vega, Blenheim Park-road, Croydon.

1883. *Finch, Gerard B., M.A. Howes Close, Cambridge.

1905. ‡Fincham, G. H. Hopewell, Invami, Cape Colony.

1905. §Findlay, Alexander, M.A., Ph.D., D.Sc., Lecturer on Physical Chemistry in the University of Birmingham.

1904. *Findlay, J. J., Ph.D., Professor of Education in the Victoria University, Manchester. Ruperra, Victoria Park, Manchester.

1902. ‡Finnegan, J., M.A., B.Sc. Kelvin House, Botanic-avenue, Belfast.

1902. ‡Fisher, J. R. Cranfield, Fortwilliam Park, Belfast.

1909. ‡Fisher, James, K.C. 216 Portage-avenue, Winnipeg, Canada.

1869. ‡FISHER, Rev. OSMOND, M.A., F.G.S. Harlton Rectory, near Cambridge.

1875. *Fisher, W. W., M.A., F.C.S. 5 St. Margaret's-road, Oxford.

1887. *Fison, Alfred H., D.Sc. 47 Dartmouth-road, Willesden Green, N.W.

1871. *FISON, Sir FREDERICK W., Bart., M.A., F.C.S. 64 Pont-street, S.W.

1883. ‡Fitch, Rev. J. J. 5 Chambres-road, Southport.

1885. *FITZGERALD, Professor MAURICE, B.A. (Local Sec. 1902.) 32 Eglantine-avenue, Belfast.

1894. ‡Fitzmaurice, Maurice, C.M.G., M.Inst.C.E. London County Council, Spring-gardens, S.W.

1888. *FITZPATRICK, Rev. THOMAS C., President of Queens' College, Cambridge.

1904. ‡Flather, J. H., M.A. Camden House, 90 Hills-road, Cambridge.

1904. ‡Fleming, James. 25 Kelvinside-terrace South, Glasgow.

1892. ‡Fletcher, George, F.G.S. 55 Pembroke-road, Dublin.

1888. *FLETCHER, LAZARUS, M.A., F.R.S., F.G.S., F.C.S. (Pres. C, 1894), *Director of the Natural History Museum, Cromwell-road, S.W.* 35 Woodville-gardens, Ealing, W.

1908. *Fletcher, W. H. B. Aldwick Manor, Bognor, Sussex.

1901. ‡Flett, J. S., M.A., D.Sc., F.R.S.E. 28 Jermyn-street, S.W.

1906. *Fleure, H. J., D.Sc., Professor of Zoology and Geology in University College, Aberystwyth.

1905. *Flint, Rev. W., D.D. Houses of Parliament, Cape Town.

1889. ‡Flower, Lady. 26 Stanhope-gardens, S.W.

1905. ‡Flowers, Frank. United Buildings, Foxburgh, Johannesburg.

1890. *FLUX, A. W., M.A. Board of Trade, Gwydyr House, Whitehall, S.W.

1877. ‡Foale, William. The Croft, Madeira Park, Tunbridge Wells.

1903. ‡Foord-Kelcey, W., Professor of Mathematics in the Royal Military Academy, Woolwich. The Shrubbery, Shooter's Hill, S.E.

Year of Election.
1911. §Foran, Charles. 72 Elm-grove, Southsea.
1906. §Forbes, Charles Mansfeldt. 14 New-street, York.
1873. *FORBES, GEORGE, M.A., F.R.S., F.R.S.E., M.Inst.C.E. 11 Little College-street, Westminster, S.W.
1883. ‡FORBES, HENRY O., LL.D., F.Z.S., Director of Museums for the Corporation of Liverpool. The Museum, Liverpool.
1875. *FORDHAM, Sir GEORGE. Odsey, Ashwell, Baldock, Herts
1909. ‡FORGET, The Hon. A. E. Regina, Saskatchewan, Canada.
1887. ‡FORREST, The Right Hon. Sir JOHN, G.C.M.G., F.R.G.S., F.G.S. Perth, Western Australia.
1902. *Forster, M. O., Ph.D., D.Sc., F.R.S. Imperial College of Science and Technology, S.W.
1883. ‡FORSYTH, A. R., M.A., D.Sc., F.R.S. (Pres. A, 1897, 1905; Council, 1907-09.) Belgrave-mansions, Grosvenor-gardens, S.W.
1911. §Foster, F. G. Ivydale, London-road, Portsmouth.
1857. *FOSTER, GEORGE CAREY, B.A., LL.D., D.Sc., F.R.S. (GENERAL TREASURER, 1898-1904; Pres. A, 1877; Council, 1871-76, 1877-82). Ladywalk, Rickmansworth.
1908. *Foster, John Arnold. 11 Hills-place, Oxford Circus, W.
1901. §Foster, T. Gregory, Ph.D., Provost of University College, London. Chester-road, Northwood, Middlesex.
1911. §FOSTER, Sir T. SCOTT, J.P. Town Hall, Portsmouth.
1911. §Foster, Lady Scott. Braemar, St. Helen's parade, Southsea.
1903. ‡Fourcade, H. G. P.O., Storms River, Humansdorp, Cape Colony.
1905. §Fowlds, Hiram. 65 Devonshire-street, Keighley, Yorkshire.
1909. §Fowlds, Mrs. 65 Devonshire-street, Keighley, Yorkshire.
1906. §Fowler, Oliver H., M.R.C.S. Ashcroft House, Cirencester.
1883. *Fox, Charles. The Pynes, Warlingham-on-the-Hill, Surrey.
1883. ‡Fox, Sir CHARLES DOUGLAS, M.Inst.C.E. (Pres. G, 1896.) Cross Keys House, 56 Moorgate-street, E.C.
1904. *Fox, Charles J. J., B.Sc., Ph.D., Professor of Chemistry in the Presidency College of Science, Poona, India.
1904. §Fox, F. Douglas, M.A., M.Inst.C.E. 19 The Square, Kensington, W.
1905. ‡Fox, Mrs. F. Douglas. 19 The Square, Kensington, W.
1883. ‡Fox, Howard, F.G.S. Rosehill, Falmouth.
1847. *Fox, Joseph Hoyland. The Cleve, Wellington, Somerset.
1900. *Fox, Thomas. Old Way House, Wellington, Somerset.
1909. *Fox, Wilson Lloyd. Carmino, Falmouth.
1908. §Foxley, Miss Barbara. M.A. 5 Norton Way North, Letchworth.
1881. *FOXWELL, HERBERT S., M.A., F.S.S. (Council, 1894-97), Professor of Political Economy in University College, London. St. John's College, Cambridge.
1907. §Fraine, Miss Ethel de, D.Sc., F.L.S. 27 Bargery-road, Catford, S.E.
1905. ‡Frames, Henry J. Talana, St. Patrick's-avenue, Parktown, Johannesburg.
1905. ‡Frames, Mrs. Talana, St. Patrick's-avenue, Parktown, Johannesburg.
1905. ‡Francke, M. P.O. Box 1156, Johannesburg.
1887. *FRANKLAND, PERCY F., Ph.D., B.Sc., F.R.S. (Pres. B, 1901), Professor of Chemistry in the University of Birmingham.
1910. *FRANKLIN, GEORGE, Litt.D. Tapton Hall, Sheffield.
1911. §FRASER, Dr. A. MEARNS. (Local Sec. 1911.) Town Hall, Portsmouth.
1911. §Fraser, Mrs. A. Mearns. Cheyne Lodge, St. Ronan's-road, Portsmouth.
1895. ‡Fraser, Alexander. 63 Church-street, Inverness.
1885. ‡FRASER, ANGUS, M.A., M.D., F.C.S. (Local Sec. 1885.) 232 Union-street, Aberdeen.

Year of
Election.

1906. *Fraser, Miss Helen C. I., D.Sc., F.L.S., Department of Botany, Birkbeck College, London. 27 Lincoln's Inn-fields, W.C.

1871. ‡Fraser, Sir Thomas R., M.D., F.R.S., F.R.S.E., Professor of Materia Medica and Clinical Medicine in the University of Edinburgh. 13 Drumsheugh-gardens, Edinburgh.

1911. §Freeman, Oliver, B.Sc. The Municipal Cottage, Portsmouth.

1884. *Fremantle, The Hon. Sir C. W., K.C.B. (Pres. F, 1892; Council, 1897–1903.) 4 Lower Sloane-street, S.W.

1906. §French, Fleet-Surgeon A. M. Langley, Beaufort-road, Kingston-on-Thames.

1909. §French, Mrs. Harriet A. Suite E, Gline's-block, Portage-avenue, Winnipeg, Canada.

1905. ‡French, Sir Somerset R., K.C.M.G. 100 Victoria street, S.W.

1886. ‡Freshfield, Douglas W., F.R.G.S. (Pres. E, 1904.) 1 Airlie-gardens, Campden Hill, W.

1901. ‡Frew, William, Ph.D. King James-place, Perth.

1887. *Fries, Harold H., Ph.D. 92 Reade-street, New York, U.S.A.

1906. ‡Fritsch, Dr. F. E. 77 Chatsworth-road, Brondesbury, N.W.

1892. *Frost, Edmund, M.D. Chesterfield-road, Eastbourne.

1882. §Frost, Edward P., J.P. West Wratting Hall, Cambridgeshire.

1911. §Frost, M. E. P. H.M. Dockyard, Portsmouth.

1887. *Frost, Robert, B.Sc. 55 Kensington-court, W.

1898. ‡Fry, The Right Hon. Sir Edward, G.C.B., D.C.L., LL.D., F.R.S., F.S.A. Failand House, Failand, near Bristol.

1905. ‡Fry, H. P.O. Box 46, Johannesburg.

1875. *Fry, Joseph Storrs. 16 Upper Belgrave-road, Clifton, Bristol.

1908. ‡Fry, M. W. J., M.A. 39 Trinity College, Dublin.

1905. *Fry, William, J.P., F.R.G.S. Wilton House, Merrion-road, Dublin.

1898. ‡Fryer, Alfred C., Ph.D. 13 Eaton-crescent, Clifton, Bristol.

1872. *Fuller, Rev. A. 7 Sydenham-hill, Sydenham, S.E.

1869. ‡Fuller, G., M.Inst.C.E. (Local Sec. 1874.) 71 Lexham-gardens, Kensington, W.

1910. ‡Gadow, H. F., Ph.D., F.R.S. Zoological Laboratory, Cambridge.

1863. *Gainsford, W. D. Skendleby Hall, Spilsby.

1906. §Gajjar, Professor T. K., M.A. Techno-Chemical Laboratory, near Girgaum Tram Terminus, Bombay.

1885. *Gallaway, Alexander. Dirgarve, Aberfeldy, N.B.

1875. ‡Galloway, W. Cardiff.

1887. *Galloway, W. J. The Cottage, Seymour-grove, Old Trafford, Manchester.

1905. ‡Galpin, Ernest E. Bank of Africa, Queenstown, Cape Colony.

1888. *Gamble, J. Sykes, C.I.E., M.A., F.R.S., F.L.S. Highfield, East Liss, Hants.

1911. §Garbett, Rev. C. F., M.A. The Vicarage, Fratton-road, Portsmouth.

1899. *Garcke, E. Ditton House, near Maidenhead.

1898. ‡Garde, Rev. C. L. Skenfrith Vicarage, near Monmouth.

1911. §Gardiner, C. I., M.A., F.G.S. 6 Paragon-parade, Cheltenham.

1905. ‡Gardiner, J. H. 59 Wroughton-road, Balham, S.W.

1900. ‡Gardiner, J. Stanley, M.A., F.R.S., Professor of Zoology and Comparative Anatomy in the University of Cambridge. Gonville and Caius College, Cambridge.

1887. ‡Gardiner, Walter, M.A., D.Sc., F.R.S. St. Awdreys, Hills-road, Cambridge.

1882. *Gardner, H. Dent, F.R.G.S. Fairmead, 46 The Goffs, Eastbourne.

Year of Election.

1905. ‡Garlick, John. Thornibrae, Green Point, Cape Town.

1905. ‡Garlick, R. C. Thornibrae, Green Point, Cape Town.

1887. *Garnett, Jeremiah. The Grange, Bromley Cross, near Bolton, Lancashire.

1882. ‡Garnett, William, D.C.L. London County Council, Victoria Embankment, W.C.

1883. ‡GARSON, J. G., M.D. (ASSIST. GEN. SEC. 1902–04.) Moorcote, Eversley, Winchfield.

1903. ‡Garstang, A. H. 120 Roe-lane, Southport.

1903. *Garstang, T. James, M.A. Bedales School, Petersfield, Hampshire.

1894. *GARSTANG, WALTER, M.A., D.Sc., F.Z.S., Professor of Zoology in the University of Leeds.

1874. *Garstin, John Ribton, M.A., LL.B., M.R.I.A., F.S.A. Bragans-town, Castlebellingham, Ireland.

1905. ‡Garthwaite, E. H. B. S. A. Co., Bulawayo, South Africa.

1889. ‡GARWOOD, Professor E. J., M.A., F.G.S. University College, Gower-street, W.C.

1905. ‡Gaskell, Miss C. J. The Uplands, Great Shelford, Cambridge.

1905. ‡Gaskell, Miss M. A. The Uplands, Great Shelford, Cambridge.

1896. *GASKELL, WALTER HOLBROOK, M.A., M.D., LL.D., F.R.S. (Pres. I, 1896; Council, 1898–1901.) The Uplands, Great Shelford, Cambridge.

1906. ‡Gaster, Leon. 32 Victoria-street, S.W.

1911. §Gates, W. 'Evening News' Office, Portsmouth.

1905. ‡Gaughren, Right Rev. Dr. M. Dutoitspan-road, Kimberley.

1905 *Gearon, Miss Susan. 55 Buckleigh-road, Streatham Common, S.W

1867. ‡GEIKIE, Sir ARCHIBALD, K.C.B., LL.D., D.Sc., Pres.R.S., F.R.S.E., F.G.S. (PRESIDENT, 1892; Pres. C, 1867, 1871, 1899; Council, 1888–1891.) Shepherd's Down, Haslemere, Surrey.

1871. ‡GEIKIE, JAMES, LL.D., D.C.L., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1889; Pres. E, 1892), Murchison Professor of Geology and Mineralogy in the University of Edinburgh. Kilmorie, Colinton-road, Edinburgh.

1898. ‡Gemmill, James F., M.A., M.D. 21 Endsleigh-gardens, Partick-hill, Glasgow.

1882. *GENESE, R. W., M.A., Professor of Mathematics in University College, Aberystwyth.

1905. ‡Gentleman, Miss A. A. 9 Abercromby-place, Stirling.

1902. *Gepp, Antony, M.A., F.L.S. British Museum (Natural History), Cromwell-road, S.W.

1899. *Gepp, Mrs. A. 7 Cumberland-road, Kew.

1884. *Gerrans, Henry T., M.A. 20 St. John-street, Oxford.

1909. ‡GIBBONS, W. M., M.A. (Local Sec. 1910.) The University, Sheffield.

1905 §Gibbs, Miss Lilian S., F.L.S. 22 South-street, Thurloe-square, S.W.

1902. ‡Gibson, Andrew. 14 Cliftonville-avenue, Belfast.

1901. §Gibson, Professor George A., M.A. 10 The University, Glasgow.

1876. *Gibson, George Alexander, M.D., D.Sc., LL.D., F.R.S.E. 3 Drumsheugh-gardens, Edinburgh.

1904. *Gibson, Mrs. Margaret D., LL.D. Castle Brae, Chesterton-lane, Cambridge.

1896. ‡GIBSON, R. J. HARVEY, M.A., F.R.S.E., Professor of Botany in the University of Liverpool.

1889. *Gibson, T. G. Lesbury House, Lesbury, R.S.O., Northumberland.

Year of Election.
1893. ‡Gibson, Walcot, F.G.S. 28 Jermyn-street, S.W.
1898. *Gifford, J. William. Oaklands, Chard.
1883. §Gilbert, Lady. Park View, Englefield Green, Surrey.
1884. *Gilbert, Philip H. 63 Tupper-street, Montreal, Canada.
1895. ‡GILCHRIST, J. D. F., M.A., Ph.D., B.Sc., F.L.S. Marine Biologist's Office. Department of Agriculture, Cape Town.
1896. *GILCHRIST, PERCY C., F.R.S., M.Inst.C.E. Reform Club, Pall Mall, S.W.
1878. ‡Giles, Oliver. Brynteg, The Crescent, Bromsgrove.
1871. *GILL, Sir DAVID, K.C.B., LL.D., D.Sc., F.R.S., Hon.F.R.S.E. (PRESIDENT, 1907.) 34 De Vere-gardens, Kensington, W.
1911. §Gill, Rev. H. V., S.J. Milltown Park, Clonskea, Co. Dublin.
1902. ‡Gill, James F. 72 Strand-road, Bootle, Liverpool.
1908. ‡Gill, T. P. Department of Agriculture and Technical Instruction for Ireland, Dublin.
1892. *Gilmour, Matthew A. B., F.Z.S. Saffronhall House, Windmill-road, Hamilton, N.B.
1907. ‡Gilmour, S. C. 25 Cumberland-road, Acton, W.
1908. ‡Gilmour, T. L. 1 St. John's Wood Park, N.W.
1893. *Gimingham, Edward. Croyland, Clapton Common, N.
1904. ‡GINN, S. R., D.L. (Local Sec. 1904.) Brookfield, Trumpington-road, Cambridge.
1884. ‡Girdwood, G. P., M.D. 28 Beaver Hall-terrace, Montreal, Canada.
1886. *Gisborne, Hartley, M.Can.S.C.E. Yoxall, Ladysmith, Vancouver Island, Canada.
1883. *Gladstone, Miss. 19 Chepstow-villas, Bayswater, W.
1871. *GLAISHER, J. W. L., M.A., D.Sc., F.R.S., F.R.A.S. (Pres. A, 1890; Council, 1878-86.) Trinity College, Cambridge.
1880. *GLANTAWE, Right Hon. Lord. The Grange, Swansea.
1881. *GLAZEBROOK, R. T., C.B., M.A., D.Sc., F.R.S. (Pres. A, 1893; Council 1890-94, 1905-11), Director of the National Physical Laboratory. Bushy House, Teddington, Middlesex.
1881. *Gleadow, Frederic. 38 Ladbroke-grove, W.
Glover, Thomas. 124 Manchester-road, Southport.
1878. *Godlee, J. Lister. Wakes Colne Place, Essex.
1880. ‡GODMAN, F. DU CANE, D.C.L., F.R.S., F.L.S., F.G.S. 10 Chandos-street, Cavendish-square, W.
1879. ‡GODWIN-AUSTEN, Lieut.-Colonel H. H., F.R.S., F.R.G.S., F.Z.S. (Pres. E, 1883.) Nore, Godalming.
1878. ‡GOFF, JAMES. (Local Sec. 1878.) 29 Lower Leeson-street, Dublin.
1908. *GOLD, ERNEST, M.A. 4 Hurst Close, Brigwood-road, Hampstead Garden Suburb, N.W.
1906. ‡GOLDIE, Right Hon. Sir GEORGE D. T., K.C.M.G., D.C.L., F.R.S. (Pres. E, 1906; Council, 1906-07.) 44 Rutland-gate, S.W.
1910. §Golding, John, F.I.C. Midland Agricultural and Dairy College, Kingston, near Derby.
1898. ‡Goldney, F. Bennett, F.S.A. Goodnestone Park, Dover.
1899. ‡GOMME, Sir G. L., F.S.A. 24 Dorset-square, N.W.
1890. *GONNER, E. C. K., M.A. (Pres. F, 1897), Professor of Political Economy in the University of Liverpool.
1909. ‡Goodair, Thomas. 303 Kennedy-street, Winnipeg, Canada.
1907. §GOODRICH, E. S., M.A., F.R.S., F.L.S. Merton College, Oxford.
1884. *Goodridge, Richard E. W. Coleraine, Minnesota, U.S.A.
1884. ‡Goodwin, Professor W. L. Queen's University, Kingston, Ontario, Canada.
1905. ‡GOOLD-ADAMS, Major Sir H. J., G.C.M.G., C.B. Government House, Bloemfontein, South Africa.

Year of Election.
1909. §Gordon, Rev. Charles W. 567 Broadway, Winnipeg, Canada.
1909. ‡Gordon, J. T. 147 Hargrave-street, Winnipeg, Canada.
1909. ‡Gordon, Mrs. J. T. 147 Hargrave-street, Winnipeg, Canada.
1911. *Gordon, J. W. 113 Broadhurst-gardens, Hampstead, N.W.
1871. *Gordon, Joseph Gordon, F.C.S. Queen Anne's-mansions, Westminster, S.W.
1893. ‡Gordon, Mrs. M. M. Ogilvie, D.Sc. 1 Rubislaw-terrace, Aberdeen.
1910. *Gordon, Vivian. Avonside Engine Works, Fishponds, Bristol.
1901. ‡GORST, Right Hon. Sir JOHN E., M.A., K.C., M.P., F.R.S. (Pres. L, 1901.) 21 Victoria-square, S.W.
1875. *GOTCH, FRANCIS, M.A., D.Sc., F.R.S. (Pres. I, 1906; Council, 1901-07), Professor of Physiology in the University of Oxford. The Lawn, Banbury-road, Oxford.
1881. ‡Gough, Rev. Thomas, B.Sc. King Edward's School, Retford.
1901. ‡GOURLAY, ROBERT. Glasgow.
1876. ‡Gow, Robert. Cairndowan, Dowanhill-gardens, Glasgow.
1883. ‡Gow, Mrs. Cairndowan, Dowanhill-gardens, Glasgow.
1873. ‡Goyder, Dr. D. Marley House, 88 Great Horton-road, Bradford, Yorkshire.
1908. §Grabham, G. W., M.A., F.G.S. P.O. Box 178, Khartoum, Sudan.
1886. ‡Grabham, Michael C., M.D. Madeira.
1909. ‡GRACE, J. H., M.A., F.R.S. Peterhouse, Cambridge.
1909. ‡Graham, Herbert W. 329 Kennedy-street, Winnipeg, Canada.
1902. *Graham, William, M.D. District Lunatic Asylum, Belfast.
1875. ‡GRAHAME, JAMES. (Local Sec. 1876.) Care of Messrs. Grahame, Crums, & Connal, 34 West George-street, Glasgow.
1904. §Gramont, Comte Arnaud de, D.Sc. 179 rue de l'Université, Paris.
1896. ‡Grant, Sir James, K.C.M.G. Ottawa, Canada.
1908. *Grant, Professor W. L. Queen's University, Kingston, Ontaria.
1905. ‡Graumann, Harry. P.O. Box 2115, Johannesburg.
1890. ‡GRAY, ANDREW, M.A., LL.D., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Glasgow.
1905. ‡Gray, C. J. P.O. Box 208, Pietermaritzburg, South Africa.
1864. *Gray, Rev. Canon Charles. West Retford Rectory, Retford.
1881. ‡Gray, Edwin, LL.B. Minster-yard, York.
1903. §Gray, Ernest, M.A. 99 Grosvenor-road, S.W.
1904. ‡GRAY, Rev. H. B., D.D. (Pres. L, 1909.) The College, Bradfield, Berkshire.
1892. *Gray, James Hunter, M.A., B.Sc. 3 Crown Office-row, Temple, E.C.
1892. §GRAY, JOHN, B.Sc. 59 Park-hill, Clapham Park, S.W.
1887. ‡Gray, Joseph W., F.G.S. 6 Richmond Park-crescent, Bournemouth.
1887. ‡Gray, M. H., F.G.S. Lessness Park, Abbey Wood, Kent.
1886. *Gray, Robert Kaye. Lessness Park, Abbey Wood, Kent.
1901. ‡Gray, R. Whytlaw. University College, W.C.
1873. ‡Gray, William, M.R.I.A. Glenburn Park, Belfast.
*GRAY, Colonel WILLIAM. Farley Hall, near Reading.
1866. §Greaves, Charles Augustus, M.B., LL.B. 84 Friar-gate, Derby.
1893. *Greaves, Mrs. Elizabeth. Station-street, Nottingham.
1910. §Greaves, R. H., B.Sc. 12 St. John's-crescent, Cardiff.
1905. ‡Green, A. F. Sea Point, Cape Colony.
1904. *Green, Professor A. G., M.Sc. The Old Gardens, Cardigan-road, Headingley, Leeds.
1904. §Green, F. W. 5 Wordsworth-grove, Cambridge.

Year of Election.

1906. §Green, J. A., M.A., Professor of Education in the University of Sheffield.

1888. §GREEN, J. REYNOLDS, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1902.) Downing College, Cambridge.

1903. ‡*Green, W. J.* *76 Alexandra-road, N.W.*

1908. ‡Green, Rev. William Spotswood, C.B., F.R.G.S. 5 Cowper-villas, Cowper-road, Dublin.

1909. ‡Greenfield, Joseph. P.O. Box 2935, Winnipeg, Canada.

1882. ‡GREENHILL, Sir A. G., M.A., F.R.S. 1 Staple Inn, W.C.

1905. ‡Greenhill, Henry H. P.O. Box 172, Bloemfontein, South Africa.

1905. ‡Greenhill, William. 6A George-street, Edinburgh.

1898. *GREENLY, EDWARD, F.G.S. Achnashean, near Bangor, North Wales.

1875. ‡Greenwood, Dr. Frederick. Brampton, Chesterfield.

1906. ‡Greenwood, Hamar. National Liberal Club, Whitehall-place, S.W.

1894. *GREGORY, J. WALTER, D.Sc., F.R.S., F.G.S. (Pres. C, 1907), Professor of Geology in the University of Glasgow.

1896. *GREGORY, Professor R. A., F.R.A.S. Dell Quay House, near Chichester.

1904. *Gregory, R. P., M.A. 156 Chesterton-road, Cambridge.

1881. ‡Gregson, William, F.G.S. 106 Victoria-road, Darlington.

1836. Griffin, S. F. Albion Tin Works, York-road, N.

1894. *Griffith, C. L. T., Assoc.M.Inst.C.E., Professor of Civil Engineering in the College of Engineering, Madras.

1908. §Griffith, John P., M.Inst.C.E. Rathmines Castle, Rathmines, Dublin.

1884. ‡GRIFFITHS, E. H., M.A., D.Sc., F.R.S. (Pres. A, 1906, Council, 1911–). Principal of University College, Cardiff.

1884. ‡Griffiths, Mrs. University College, Cardiff.

1903. ‡Griffiths, Thomas, J.P. 101 Manchester-road, Southport.

1888. *Grimshaw, James Walter, M.Inst.C.E. St. Stephen's Club, Westminster, S.W.

1911. §Grogan, Ewart S. Camp Hill, near Newcastle, Staffs.

1804. ‡GROOM, Professor P., M.A., F.L.S. North Park, Gerrard's Cross, Bucks.

1894. ‡Groom, T. T., M.A., D.Sc., F.G.S., Professor of Geology in the University of Birmingham.

1909. *Grossman, Edward L., M.D. Steilacoom, Washington, U.S.A.

1896. ‡Grossmann, Dr. Karl. 70 Rodney-street, Liverpool.

1904. ‡Grosvenor, G. H. New College, Oxford.

1869. ‡GRUBB, Sir HOWARD, F.R.S., F.R.A.S. Aberfoyle, Rathgar, Dublin.

1897. ‡Grünbaum, A. S., M.A., M.D. School of Medicine, Leeds.

1910. §Grundy, James. 8 Grosvenor-gardens, Cricklewood, N.W.

1887. ‡GUILLEMARD, F. H. H., M.A., M.D. The Mill House, Trumpington, Cambridge.

1905. *Gunn, Donald. Royal Societies Club, St. James's-street, S.W.

1909. ‡Gunne, J. R., M.D. Kenora, Ontario, Canada.

1909. ‡Gunne, W. J., M.D. Kenora, Ontario, Canada.

1866. ‡GÜNTHER, ALBERT C. L. G., M.A., M.D., Ph.D., F.R.S., F.L.S., F.Z.S. (Pres. D, 1880.) 22 Lichfield-road, Kew, Surrey.

1894. ‡Günther, R. T. Magdalen College, Oxford.

1880. §Guppy, John J. Ivy-place, High-street, Swansea.

1904. §Gurney, Sir Eustace. Sprowston Hall, Norwich.

1902. *Gurney, Robert. Ingham Old Hall, Stalham, Norfolk.

1904. ‡Guttmann, Professor Leo F., Ph.D. Queen's University, Kingston, Canada.

Year of
Election.

1905. ‡Hacker, Rev. W. J. Idutywa, Transkei, South Africa.
1908. *Hackett, Felix E. Royal College of Science, Dublin.
1881. *HADDON, ALFRED CORT, M.A., D.Sc., F.R.S., F.Z.S. (Pres. H, 1902, 1905; Council, 1902–08, 1910– .) Inisfail, Hills-road, Cambridge.
1911. *Haddon, Miss Kathleen. Inisfail, Hills-road, Cambridge.
1888 *Hadfield, Sir R. A., F.R.S., M.Inst.C.E. Parkhead House, Sheffield.
1905. ‡Hahn, Professor P. D., M.A., Ph.D. York House, Gardens, Cape Town.
1911. §Haigh, B. P., B.Sc. James Watt Engineering Laboratory, The University, Glasgow.
1906. ‡Hake, George W. Oxford, Ohio, U.S.A
1894. †HALDANE, JOHN SCOTT, M.A , M.D., F.R.S. (Pres. I, 1908), Reader in Physiology in the University of Oxford, Cherwell, Oxford.
1909. §Hale, W. H., Ph.D. 40 First-place, Brooklyn, New York, U.S.A.
1911. §Halket, Miss A. C. Waverley House, 135 East India-road, E.
1899. ‡HALL, A. D., M.A., F.R.S. (Council, 1908–), Director of the Rothamsted Experimental Station, Harpenden, Herts.
1909. §Hall, Archibald A., M.Sc., Ph.D. Armstrong College, Newcastle-on-Tyne.
1903. ‡HALL, E. MARSHALL, K.C. 75 Cambridge-terrace, W.
1879. *Hall, Ebenezer. Abbeydale Park, near Sheffield.
1883. *Hall. Miss Emily. 63 Belmont-street, Southport.
1854. *HALL, HUGH FERGIE, F.G.S. Cissbury Court, West Worthing, Sussex.
1899. ‡Hall, John, M.D. National Bank of Scotland, 37 Nicholas-lane, E.C.
1884. §Hall, Thomas Proctor, M.D. 1301 Davie-street, Vancouver, B.C., Canada.
1908. *Hall, Wilfred, Assoc.M.Inst.C.E. 9 Prior's-terrace, Tynemouth, Northumberland.
1891. *Hallett, George. Cranford, Victoria-square, Penarth.
1873. *HALLETT, T. G. P., M.A. Claverton Lodge, Bath.
1888. §HALLIBURTON, W. D., M.D., LL.D., F.R.S. (Pres. I, 1902; Council, 1897–1903, 1911–), Professor of Physiology in King's College, London. Church Cottage, 17 Marylebone-road, N.W.
1905. ‡Halliburton, Mrs. Church Cottage, 17 Marylebone-road, N.W.
1904. *Hallidie, A. H. S. Avondale, Chesterfield-road, Eastbourne.
1908. ‡Hallitt, Mrs. Steeple Grange, Wirksworth.
1908. *Hamel, Egbert Alexander de. Middleton Hall, Tamworth.
1883. *Hamel, Egbert D. de. Middleton Hall, Tamworth.
1904. *Hamel de Manin, Anna Countess de. 35 Circus-road, N.W.
1906. ‡Hamill, John Molyneux, M.A., M.B. 14 South-parade, Chiswick.
1906. ‡Hamilton, Charles I. 88 Twyford-avenue, Acton.
1909. ‡Hamilton, F. C. Bank of Hamilton-chambers, Winnipeg, Canada.
1902. ‡HAMILTON, Rev. T., D.D. Queen's College, Belfast.
1909. ‡Hamilton, T. Glen, M.D. 264 Renton-avenue, Winnipeg, Canada.
1905. ‡Hammersley-Heenan, R. H., M.Inst.C.E. Harbour Board Offices, Cape Town.
1905. ‡Hammond, Miss Edith. High Dene, Woldingham, Surrey.
1881. *HAMMOND, ROBERT, M.Inst.C.E. 64 Victoria-street, Westminster, S.W.
1899. *Hanbury, Daniel. Lenqua da Cà, Alassio, Italy.
1878. ‡Hance, E. M. Care of J. Hope Smith, Esq., 3 Leman-street, E.C.
1909. ‡Hancock, C. B. Manitoba Government Telephones, Winnipeg, Canada.
1905. *Hancock, Strangman. Kennel Holt, Cranbrook, Kent.

Year of
Election.

1911. §Hann, H. F. 139 Victoria-road North, Southsea.
1906. §Hanson, David. Salterlee, Halifax, Yorkshire.
1904. §Hanson, E. K. 2A The Parade, High-street, Watford; and Woodthorpe, Royston Park-road, Hatch End, Middlesex.
1859. *HARCOURT, A. G. VERNON, M.A., D.C.L., LL.D., D.Sc., F.R.S., V.P.C.S. (GEN. SEC. 1883-97; Pres. B, 1875; Council, 1881-83.) St. Clare, Ryde, Isle of Wight.
1909. §Harcourt, George. Department of Agriculture, Edmonton, Alberta, Canada.
1886. *Hardcastle, Colonel Basil W., F.S.S. 12 Gainsborough-gardens, Hampstead, N.W.
1902. *HARDCASTLE, Miss FRANCES. 3 Osborne-terrace, Newcastle-on-Tyne.
1903. *Hardcastle, J. Alfred. The Dial House, Crowthorne, Berkshire.
1892. *HARDEN, ARTHUR, Ph.D., D.Sc., F.R.S. Lister Institute of Preventive Medicine, Chelsea-gardens, Grosvenor-road, S.W.
1905. ‡Hardie, Miss Mabel, M.B. High-lane, *viâ* Stockport.
1877. ‡Harding, Stephen. Bower Ashton, Clifton, Bristol.
1894. ‡Hardman, S. C. 120 Lord-street, Southport.
1909. §HARDY, W. B., M.A., F.R.S. Gonville and Caius College, Cambridge.
1881. ‡Hargrove, William Wallace. St. Mary's, Bootham, York
1890. *HARKER, ALFRED, M.A., F.R.S., F.G.S. (Pres. C, 1911.) St. John's College, Cambridge.
1896. ‡Harker, John Allen, D.Sc., F.R.S. National Physical Laboratory, Bushy House, Teddington.
1875. *Harland, Rev. Albert Augustus, M.A., F.G.S., F.L.S., F.S.A. The Vicarage, Harefield, Middlesex.
1905. ‡Harland, H. C. P.O. Box 1024, Johannesburg.
1877. *Harland, Henry Seaton. 8 Arundel-terrace, Brighton.
1883. *Harley, Miss Clara. Rastrick, Cricketfield-road, Torquay.
1899. ‡Harman, Dr. N. Bishop, F.R.C.S. 108 Harley street, W.
1868. *HARMER, F. W., F.G.S. Oakland House, Cringleford, Norwich.
1881. *HARMER, SIDNEY F., M.A., Sc.D., F.R.S. (Pres. D, 1908.) Keeper of the Department of Zoology, British Museum (Natural History), Cromwell-road, S.W.
1906. ‡Harper, J. B. 16 St. George's-place, York.
1842. *Harris, G. W. Millicent, South Australia.
1909. ‡Harris, J. W. Civic Offices, Winnipeg.
1903. ‡Harris, Robert, M.B. Queen's-road, Southport.
1904. *Harrison, Frank L., B.A. The Grammar School, Soham, Cambridgeshire.
1904. ‡Harrison, H. Spencer. The Horniman Museum, Forest-hill, S.E.
1892. ‡HARRISON, JOHN. (Local Sec. 1892.) Rockville, Napier-road, Edinburgh.
1870. ‡HARRISON, REGINALD, F.R.C.S. (Local Sec. 1870.) 6 Lower Berkeley-street, Portman-square, W.
1892. ‡Harrison, Rev. S. N. Ramsey, Isle of Man.
1901. *Harrison, W. E. 17 Soho-road, Handsworth, Staffordshire.
1911. §Harrison-Smith, F., C.B. H.M. Dockyard, Portsmouth.
1885. ‡HART, Colonel C. J. (Local Sec. 1886.) Highfield Gate, Edgbaston, Birmingham.
1909. ‡Hart, John A. 120 Emily-street, Winnipeg, Canada.
1876. *Hart, Thomas. Brooklands, Blackburn.
1903. *Hart, Thomas Clifford. Brooklands, Blackburn.
1907. §Hart, W. E. Kilderry, near Londonderry.
1911. §Hart-Synnot, Ronald V.O. University College, Reading.

Year of Election.

1893. *HARTLAND, E. SIDNEY, F.S.A. (Pres. H, 1906 ; Council, 1906- .) Highgarth, Gloucester.

1905. ‡Hartland, Miss. Highgarth, Gloucester.

1871. *HARTLEY, Sir WALTER NOEL, D.Sc., F.R.S., F.R.S.E., F.C.S. (Pres. B, 1903.) 10 Elgin-road, Dublin.

1886. *HARTOG, Professor M. M., D.Sc. University College, Cork.

1887. ‡HARTOG, P. J., B.Sc. University of London, South Kensington, S.W.

1911. §Harvey, Thomas H. Blackbrook-grove, Fareham, Hants.

1905. ‡Harvey-Hogan, J. P.O. Box 1277, Johannesburg.

1885. §Harvie-Brown, J. A. Dunipace, Larbert, N.B.

1862. *Harwood, John. Woodside Mills, Bolton-le-Moors.

1893. §Haslam, Lewis. 44 Evelyn-gardens, S.W.

1911. *Hassé, H. R. The University, Manchester.

1903. *Hastie, Miss J. A. Care of Messrs. Street & Co., 30 Cornhill, E.C.

1904. ‡HASTINGS, G. 15 Oak-lane, Bradford, Yorkshire.

1875. *HASTINGS, G. W. (Pres. F. 1880.) Chapel House, Chipping Norton.

1903. ‡Hastings, W. G. W. 2 Halsey-street, Cadogan-gardens, S.W.

1889. ‡HATCH, F. H., Ph.D., F.G.S. Southacre, Trumpington-road, Cambridge.

1903. ‡Hathaway, Herbert G 45 High-street, Bridgnorth, Salop.

1904. *Haughton, W. T. H. The Highlands, Great Barford, St. Neots.

1908. §Havelock, T. H. Rockliffe, Gosforth, Newcastle-on-Tyne.

1904. ‡Havilland, Hugh de. Eton College, Windsor.

1887. *Hawkins, William. Earlston House, Broughton Park, Manchester.

1872. *Hawkshaw, Henry Paul. 58 Jermyn-street, St. James's, S.W.

1864. *HAWKSHAW, JOHN CLARKE, M.A., M.Inst.C.E., F.G.S. (Council, 1881-87.) 22 Down-street, W.

1897. §HAWKSLEY, CHARLES, M.Inst.C.E., F.G.S. (Pres. G, 1903 ; Council, 1902-09.) Caxton House (West Block), Westminster, S.W.

1887. *Haworth, Jesse. Woodside, Bowdon, Cheshire.

1861. *HAY, Admiral the Right Hon. Sir JOHN C. D., Bart., G.C.B., D.C.L., F.R.S. 108 St. George's-square, S.W.

1885. *HAYCRAFT, JOHN BERRY, M.D., B.Sc., F.R.S.E., Professor of Physiology in University College, Cardiff.

1900. §Hayden, H. H., B.A., F.G.S. Geological Survey, Calcutta, India.

1903. *Haydock, Arthur. 37 Houghton-street, Blackburn.

1903. ‡Hayward, Joseph William, M.Sc. Keldon, St. Marychurch, Torquay.

1896. *Haywood, Colonel A. G. Rearsby, Merrilocks-road, Blundellsands.

1883. ‡Heape, Joseph R. Glebe House, Rochdale.

1882. *Heape, Walter, M.A., F.R.S. Greyfriars, Southwold, Suffolk.

1909. §Heard, Mrs. Sophie, M.B., Ch.B. 81 Craigla-drive, Edinburgh.

1908. §Heath, J. St. George, B.A. Woodbrooke Settlement, Selly Oak, near Birmingham.

1902. ‡Heath, J. W. Royal Institution, Albemarle-street, W.

1909. ‡Heathcote, F. C. C. Broadway, Winnipeg, Canada.

1883. ‡Heaton, Charles. Marlborough House, Hesketh Park, Southport.

1892. *HEATON, WILLIAM H., M.A. (Local Sec. 1893), Professor of Physics in University College, Nottingham.

1889. *Heaviside, Arthur West, I.S.O. 12 Tring-avenue, Ealing, W.

1888. *HEAWOOD, EDWARD, M.A. Briarfield, Church-hill, Merstham, Surrey.

1888. *Heawood, Percy J., Lecturer in Mathematics in Durham University. 41 Old Elvet, Durham.

Year of Election.

1887. *HEDGES, KILLINGWORTH, M.Inst.C.E. 10 Cranley-place, South Kensington, S.W.

1881. *HELE-SHAW, H. S., LL.D., F.R.S., M.Inst.C.E. 64 Victoria-street, S.W.

1901. *HELLER, W. M., B.Sc. 40 Upper Sackville-street, Dublin.

1905. ‡Hellman, Hugo. Rand Club, Johannesburg.

1911. §Hellyer, Francis E. Farlington House, Havant, Hants.

1911. §Hellyer, George E. Farlington House, Havant, Hants.

1887. ‡Hembry, Frederick William, F.R.M.S. City-chambers, 2 St. Nicholas-street, Bristol.

1899. ‡Hemsalech, G. A., D.Sc. The Owens College, Manchester.

1905. *Henderson, Andrew. 17 Belhaven-terrace, Glasgow.

1905. *Henderson, Miss Catharine. 17 Belhaven-terrace, Glasgow.

1891. *HENDERSON, G. G., D.Sc., M.A., F.I.C., Professor of Chemistry in the Glasgow and West of Scotland Technical College, Glasgow.

1905. §Henderson, Mrs. Technical College, Glasgow.

1907. ‡Henderson, H. F. Felday, Morland-avenue, Leicester.

1906. ‡Henderson, J. B., D.Sc., Professor of Applied Mechanics in the Royal Naval College, Greenwich, S.E.

1909. ‡Henderson, Veylien E. Medical Building, The University, Toronto, Canada.

1909. ‡Henderson, W. G. Louise Bridge, Winnipeg, Canada.

1880. *Henderson, Admiral W. H., R.N. 12 Vicarage-gardens, Campden Hill, W.

1911. §Henderson, William Dawson. The University, Bristol.

1904. *Hendrick, James. Marischal College, Aberdeen.

1910. §Heney, T. W. Sydney, New South Wales.

1910. *HENRICI, Captain E. O., R.E., A.Inst.C.E. Ordnance Survey Office, Southampton.

1873. *HENRICI, OLAUS M. F. E., Ph.D., F.R.S. (Pres. A, 1883; Council, 1883-89.) 34 Clarendon-road, Notting Hill, W.

1910. ‡Henry, Hubert, M.D. 304 Glossop-road, Sheffield.

1906. ‡Henry, Dr. T. A. Imperial Institute, S.W.

1909. *Henshall, Robert. Sunnyside, Latchford, Warrington.

1892. ‡HEPBURN, DAVID, M.D., F.R.S.E., Professor of Anatomy in University College, Cardiff.

1904. †Hepworth, Commander M. W. C., C.B., R.N.R. Meteorological Office, South Kensington, S.W.

1892. *HERBERTSON, A. J., M.A., Ph.D. (Pres. E, 1910). Professor of Geography in the University of Oxford. 43 Banbury-road, Oxford.

1909. ‡Herbinson, William. 376 Ellice-avenue, Winnipeg, Canada.

1902. ‡Herdman, G. W., B.Sc., Assoc.M.Inst.C.E. Irrigation and Water Supply Department, Pretoria.

1887. *HERDMAN, WILLIAM A., D.Sc., F.R.S., F.R.S.E., F.L.S. (GENERAL SECRETARY, 1903- ; Pres. D, 1895; Council, 1894-1900; Local Sec. 1896), Professor of Natural History in the University of Liverpool. Croxteth Lodge, Sefton Park, Liverpool.

1893. *Herdman, Mrs. Croxteth Lodge, Sefton Park, Liverpool.

1909. ‡Herdt, Professor L. A. McGill University, Montreal, Canada.

1875. ‡HEREFORD, The Right Rev. JOHN PERCIVAL, D.D., LL.D., Lord Bishop of. (Pres. L, 1904.) The Palace, Hereford.

1908. *Herring, Dr. Percy T. The University, St. Andrews, N.B.

1874. ‡HERSCHEL, Colonel JOHN, R.E., F.R.S., F.R.A.S. Observatory House, Slough, Bucks.

1900. *Herschel, Rev. J. C. W. Fircroft, Wellington College Station, Berkshire.

Year of Election.

1905. ‡Hervey, Miss Mary F. S. 22 Morpeth-mansions, S.W.
1903. *HESKETH, CHARLES H. FLEETWOOD, M.A. Stocken Hall, Stretton, Oakham.
1895. §Hesketh, James. 5 Scarisbrick Avenue, Southport.
1905. ‡Hewat, M. L., M.D. Mowbray, near Cape Town, South Africa.
1894. ‡HEWETSON, G. H. (Local Sec. 1896.) 39 Henley-road, Ipswich.
1894. ‡Hewins, W. A. S., M.A., F.S.S. 15 Chartfield-avenue, Putney Hill, S.W.
1908. ‡Hewitt, Dr. C. Gordon. Central Experimental Farm, Ottawa.
1896. §Hewitt, David Basil, M.D. Oakleigh, Northwich, Cheshire.
1903. ‡Hewitt, E. G. W. 87 Princess-road, Moss Side, Manchester.
1909. §Hewitt, Sir F. W., M.V.O., M.D. 14 Queen Anne-street, W.
1903. ‡Hewitt, John Theodore, M.A., D.Sc., Ph.D., F.R.S. Clifford House, Staines-road, Bedfont, Middlesex.
1909. ‡Hewitt, W., B.Sc. 16 Clarence-road, Birkenhead.
1882. *HEYCOCK, CHARLES T., M.A., F.R.S. 3 St. Peter's-terrace, Cambridge.
1883. ‡Heyes, Rev. John Frederick, M.A., F.R.G.S. St. Barnabas Vicarage, Bolton.
1866. *Heymann, Albert. West Bridgford, Nottinghamshire.
1901. *Heys, Z. John. Stonehouse, Barrhead, N.B.
1886. ‡HEYWOOD, HENRY, J.P. Witla Court, near Cardiff.
1898. ‡Hicks, Henry B. 44 Pembroke-road, Clifton, Bristol.
1877. §HICKS, W. M., M.A., D.Sc., F.R.S. (Vice-Pres. 1910; Pres. A, 1895), Professor of Physics in the University of Sheffield. Leamhurst, Ivy Park-road, Sheffield.
1886. ‡Hicks, Mrs. W. M. Leamhurst, Ivy Park-road, Sheffield.
1887. *HICKSON, SYDNEY J., M.A., D.Sc., F.R.S. (Pres. D, 1903), Professor of Zoology in Victoria University, Manchester.
1864. *HIERN, W. P., M.A., F.R.S. The Castle, Barnstaple.
1891. ‡HIGGS, HENRY, C.B., LL.B., F.S.S. (Pres. F, 1899; Council, 1904–06.) H.M. Treasury, Whitehall, S.W.
1909. ‡Higman, Ormond. Electrical Standards Laboratory, Ottawa.
1907. ‡HILEY, E. V. (Local Sec. 1907.) Town Hall, Birmingham.
1911. *Hiley, Wilfrid E. Ebbor, Wells, Somerset.
1885. *HILL, ALEXANDER, M.A., M.D. Brookland, Royston, Herts.
1903. *HILL, ARTHUR W., M.A., F.L.S. Royal Gardens, Kew.
1906. §Hill, Charles A., M.A., M.B. 13 Rodney-street, Liverpool.
1881. *HILL, Rev. EDWIN, M.A. The Rectory, Cockfield, Bury St. Edmunds.
1908. *Hill, James P., D.Sc., Professor of Zoology in University College, Gower-street, W.C.
1911. §Hill, Leonard, M.B., F.R.S. Osborne House, Loughton, Essex.
1886. ‡HILL, M. J. M., M.A., D.Sc., F.R.S., Professor of Pure Mathematics in University College, W.C.
1898. *Hill, Thomas Sidney. 143 Alexandra-road, St. John's Wood, N.W.
1888. ‡Hill, William, F.G.S. The Maples, Hitchin, Herts.
1907. *HILLS, Major E. H., C.M.G., R.E., F.R.S., F.R.G.S. (Pres. E, 1908.) 32 Prince's-gardens, S.W.
1911. *Hills, William Frederick Waller. 32 Prince's-gardens, S.W.
1903. *Hilton, Harold. 73 Platt's-lane, Hampstead, N.W.
1903. *HIND, WHEELTON, M.D., F.G.S. Roxeth House, Stoke-on-Trent.
1870. ‡HINDE, G. J., Ph.D., F.R.S., F.G.S. Ivythorn, Avondale-road, South Croydon, Surrey.
1910. §Hindle, Dr. Edward. Quick Laboratory, Cambridge.

Year of Election.

1883. *Hindle, James Henry. 8 Cobham-street, Accrington.
1888. *Hindmarsh, W. T., F.L.S. Alnbank, Alnwick.
1898. §Hinds, Henry. 57 Queen-street, Ramsgate.
1900. ‡Hinks, Arthur R., M.A. The Observatory, Cambridge.
1903. *Hinmers, Edward. Glentwood, South Downs-drive, Hale, Cheshire.
1911. §Hitchcock, Miss A. M., M.A. 40 St. Andrew's-road, Southsea.
1899. ‡Hobday, Henry. Hazelwood, Crabble Hill, Dover.
1887. *Hobson, Bernard, M.Sc., F.G.S. Thornton, Hallam Gate-road, Sheffield.
1883. ‡Hobson, Mrs. Carey. 5 Beaumont-crescent, West Kensington, W.
1904. ‡HOBSON, ERNEST WILLIAM, Sc.D., F.R.S. (Pres. A, 1910). Sadlerian Professor of Pure Mathematics in the University of Cambridge. The Gables, Mount Pleasant, Cambridge.
1907. ‡Hobson, Mrs. Mary. 6 Hopefield-avenue, Belfast.
1877. ‡Hodge, Rev. John Mackey, M.A. 38 Tavistock-place, Plymouth.
1887. *Hodgkinson, Alexander, M.B., B.Sc., Lecturer on Laryngology in the Victoria University, Manchester. 18 St. John-street, Manchester.
1880. ‡Hodgkinson, W. R. Eaton, Ph.D., F.R.S.E., F.G.S., Professor of Chemistry and Physics in the Royal Artillery College, Woolwich. 18 Glenluce-road, Blackheath, S.E.
1905. ‡Hodgson, Ven Archdeacon R. The Rectory, Wolverhampton.
1909. ‡Hodgson, R. T., M.A. Collegiate Institute, Brandon, Manitoba, Canada.
1898. ‡Hodgson, T. V. Municipal Museum and Art Gallery, Plymouth.
1904. §Hodson, F. Bedales School, Petersfield, Hampshire
1904. ‡HOGARTH, D. G., M.A. (Pres. H, 1907; Council, 1907–10.) 20 St. Giles's, Oxford.
1894. ‡*Hogg, A. F., M.A.* 13 *Victoria-road, Darlington.*
1908. ‡Hogg, Right Hon. Jonathan. Stratford, Rathgar, Co. Dublin.
1911. §Holbrook, Colonel A. R. Warleigh, Grove-road South, Southsea.
1907. ‡Holden, Colonel H. C. L., R.A., F.R.S. Gifford House, Blackheath, S.E.
1883. ‡Holden, John J. 73 Albert-road, Southport.
1887. *Holder, Henry William, M.A. Beechmount, Arnside.
1900. ‡HOLDICH, Colonel Sir THOMAS H., R.E., K.C.B., K.C.I.E., F.R.G.S. (Pres. E, 1902.) 41 Courtfield-road, S.W.
1887. *Holdsworth, C. J., J.P. Fernhill, Alderley Edge, Cheshire.
1904. §Holland, Charles E. 9 Downing-place, Cambridge.
1903. §Holland, J. L., B.A. 3 Primrose-hill, Northampton.
1896. ‡Holland, Mrs. Lowfields House, Hooton, Cheshire.
1898. ‡HOLLAND, Sir THOMAS H., K.C.I.E., F.R.S., F.G.S., Professor of Geology in the Victoria University, Manchester.
1889. ‡Holländer, Bernard, M.D. 35A Welbeck-street, W.
1906. *Hollingworth, Miss. Leithen, Newnham-road, Bedford.
1905. ‡Hollway, H. C. Schunke. Plaisir de Merle, P.O. Simondium, *viâ* Paarl, South Africa.
1883. *Holmes, Mrs. Basil. 23 Corfton-road, Ealing, Middlesex, W.
1866. *Holmes, Charles. Makeney, Compton-road, Winchmore Hill, N.
1882. *HOLMES, THOMAS VINCENT, F.G.S. 28 Croom's-hill, Greenwich, S.E.
1903. *HOLT, ALFRED, M.A., D.Sc. Crofton, Aigburth, Liverpool.
1875. *Hood, John. Chesterton, Cirencester.
1904. §Hooke, Rev. D. Burford, D.D. Bonchurch Lodge, Barnet.
1892. ‡*HOOKER, REGINALD H., M.A.* 3 *Clement's Inn, W.C.*
1908. *Hooper, Frank Henry. Clare College, Cambridge.
1865. *Hooper, John P. Deepdene, Streatham Common, S.W.

Year of Election.

1877. *Hooper, Rev. Samuel F., M.A. Lydlinch Rectory, Sturminster Newton, Dorset.

1904. ‡Hopewell-Smith, A., M.R.C.S. 37 Park-street, Grosvenor-square, S.W.

1905. *Hopkins, Charles Hadley. Junior Constitutional Club, 101 Piccadilly, W.

1901. *HOPKINSON, BERTRAM, M.A., F.R.S., F.R.S.E., Professor of Mechanism and Applied Mechanics in the University of Cambridge. Adams-road, Cambridge.

1884. *HOPKINSON, CHARLES. (Local Sec. 1887.) The Limes, Didsbury, near Manchester.

1882. *Hopkinson, Edward, M.A., D.Sc. Ferns, Alderley Edge, Cheshire.

1871. *HOPKINSON, JOHN, Assoc.Inst.C.E., F.L.S., F.G.S., F.R.Met.Soc. Westwood, Watford.

1905. ‡Hopkinson, Mrs. John. Holmwood, Wimbledon Common, S.W.

1898. *Hornby, R., M.A. Haileybury College, Hertford.

1910. §Horne, Arthur S. 48 Highbury, Newcastle-on-Tyne.

1885. ‡HORNE, JOHN, LL.D., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1901.) Geological Survey Office, Sheriff Court-buildings, Edinburgh.

1903. ‡Horne, William, F.G.S. Leyburn, Yorkshire.

1902. ‡Horner, John. Chelsea, Antrim-road, Belfast.

1905. *Horsburgh, E. M., M.A., B.Sc., Lecturer in Technical Mathematics in the University of Edinburgh.

1887. ‡Horsfall, T. C. Swanscoe Park, near Macclesfield.

1893. *HORSLEY, Sir VICTOR A. H., LL.D., B.Sc., F.R.S., F.R.C.S. (Council, 1893–98.) 25 Cavendish-square, W.

1908. ‡Horton, F. St. John's College, Cambridge.

1884. *Hotblack, G. S. Brundall, Norwich.

1899. ‡Hotblack, J. T., F.G.S. 45 Newmarket-road, Norwich.

1906. *Hough, Miss Ethel M. Codsall Wood, near Wolverhampton.

1859. ‡Hough, Joseph, M.A., F.R.A.S. Codsall Wood, Wolverhampton.

1896. *Hough, S. S., M.A., F.R.S., F.R.A.S., His Majesty's Astronomer at the Cape of Good Hope. Royal Observatory, Cape Town.

1905. §Houghting, A. G. L. Glenelg, Musgrave-road, Durban, Natal.

1905. ‡Houseman, C. L. P.O. Box 149, Johannesburg.

1908. ‡Houston, David, F.L.S. Royal College of Science, Dublin.

1904. *Howard, Mrs. G. L. C. Agricultural Research Institute, Pusa, Bengal, India.

1887. *Howard, S. S. 54 Albemarle-road, Beckenham, Kent.

1901. §Howarth, E., F.R.A.S. Public Museum, Weston Park, Sheffield.

1903. *Howarth, James H., F.G.S. Holly Bank, Halifax.

1907. ‡HOWARTH, O. J. R., M.A. (ASSISTANT SECRETARY.) 24 Lansdowne-crescent, W.

1911. *Howe, Professor G. W. O., M.Sc. 14 Barnard-gardens, Wimbledon, S.W.

1905. ‡Howick, Dr. W. P.O. Box 503, Johannesburg.

1863. ‡HOWORTH, Sir H. H., K.C.I.E., D.C.L., F.R.S., F.S.A. 30 Collingham-place, Cromwell-road, S.W.

1887. §HOYLE, WILLIAM E., M.A., D.Sc. (Pres. D, 1907.) National Museum of Wales, City Hall, Cardiff.

1903. ‡Hübner, Julius. Ash Villa, Cheadle Hulme, Cheshire.

1898. ‡Hudson, Mrs. Sunny Bank, Egerton, Huddersfield.

1867. *HUDSON, Professor WILLIAM H. H., M.A., LL.M. 34 Birdhurst-road, Croydon.

1871. *Hughes, George Pringle, J.P., F.R.G.S. Middleton Hall, Wooler, Northumberland.

Year of Election.

1868. ‡HUGHES, T. M'K., M.A., F.R.S., F.G.S. (Council, 1879-86), Woodwardian Professor of Geology in the University of Cambridge. Ravensworth, Brooklands-avenue, Cambridge.
1867. ‡HULL, EDWARD, M.A., LL.D., F.R.S., F.G.S. (Pres. C, 1874.) 14 Stanley-gardens, Notting Hill, W.
1903. ‡Hulton, Campbell G. Palace Hotel, Southport.
1905. §Hume, Dr. G. W. 55 Gladstone-street, Dundee, Natal.
1911. *Hume, Dr. W. F. Helwan, Egypt.
1904. *Humphreys, Alexander C., Sc.D., LL.D., President of the Stevens Institute of Technology, Hoboken, New Jersey, U.S.A.
1907. §Humphries, Albert E. Coxe's Lock Mills, Weybridge.
1877. *HUNT, ARTHUR ROOPE, M.A., F.G.S. Southwood, Torquay.
1891. *Hunt, Cecil Arthur. Southwood, Torquay.
1881. ‡Hunter, F. W. 16 Old Elvet, Durham.
1889. ‡Hunter, Mrs. F. W. 16 Old Elvet, Durham.
1909. ‡Hunter, W. J. H. 31 Lynedoch-street, Glasgow.
1901. *Hunter, William. Evirallan, Stirling.
1903. ‡Hurst, Charles C., F.L.S. Burbage, Hinckley.
1861. *Hurst, William John. Drumaness, Ballynahinch, Co. Down, Ireland.
1894. *HUTCHINSON, A., M.A., Ph.D. (Local Sec. 1904.) Pembroke College, Cambridge.
1903. §Hutchinson, Rev. H. N. 17 St. John's Wood Park, Finchley-road, N.W.
1864. *Hutton, Darnton. 14 Cumberland-terrace, Regent's Park, N.W.
1887. *Hutton, J. Arthur. The Woodlands, Alderley Edge, Cheshire.
1908. ‡Hutton, Lucius O. Wyckham, Dundrum, Co. Dublin.
1901. *Hutton, R. S., D.Sc. West-street, Sheffield.
1871. *Hyett, Francis A. Painswick House, Painswick, Stroud, Gloucestershire.
1900. *Hyndman, H. H. Francis. 5 Warwick-road, Earl's Court, S.W.

1908. ‡Idle, George. 43 Dawson-street, Dublin.
1883. ‡Idris, T. H. W. 110 Pratt-street, Camden Town, N.W.
1884. *Iles, George. 5 Brunswick-street, Montreal, Canada.
1906. ‡Iliffe, J. W. Oak Tower, Upperthorpe, Sheffield.
1885. ‡im Thurn, Sir Everard F., C.B., K.C.M.G. 1 East India-avenue, Leadenhall-street, E.C.
1888. *Ince, Surgeon-Major John, M.D. Montague House, Swanley, Kent.
1907. §Ingham, Charles B. Moira House, Eastbourne.
1905. ‡Ingham, W. Engineer's Office, Sand River, Uitenhage.
1893. ‡Ingle, Herbert. Department of Agriculture, Pretoria.
1901. ‡INGLIS, JOHN, LL.D. 4 Prince's-terrace, Dowanhill, Glasgow.
1905. §Innes, R. T. A., F.R.A.S. Meteorological Observatory, Johannesburg.
1901. *Ionides, Stephen A. 929 Foster-building, Denver, Colorado.
1882. §IRVING, Rev. A., B.A., D.Sc. Hockerill Vicarage, Bishop's Stortford, Herts.
1908. ‡Irwin, Alderman John. 33 Rutland-square, Dublin.

1876. *JACK, WILLIAM, LL.D., Professor of Mathematics in the University of Glasgow. 10 The University, Glasgow.
1909. ‡Jacks, Professor L. P. 28 Holywell, Oxford.
1883. *Jackson, Professor A. H., B.Sc. 349 Collins-street, Melbourne, Australia.

Year of Election.

1903. ‡Jackson, C. S. Royal Military Academy, Woolwich, S.E.
1883. *Jackson, F. J. 35 Leyland-road, Southport.
1883. ‡Jackson, Mrs. F. J. 35 Leyland-road, Southport.
1874. *Jackson, Frederick Arthur. Belmont, Somenos, Vancouver Island, B.C., Canada.
1899. ‡Jackson, Geoffrey A. 31 Harrington-gardens, Kensington, S.W.
1897. §Jackson, James, F.R.Met.Soc. Seabank, Girvan, N.B.
1906. *Jackson, James Thomas, M.A. Engineering School, Trinity College, Dublin.
1898. *Jackson, Sir John. 51 Victoria-street, S.W.
1905. ‡Jacobsohn, Lewis B. Lloyd's-buildings, 58 Burg-street, Cape Town.
1905. ‡Jacobsohn, Sydney Samuel. Lloyd's-buildings, 58 Burg-street, Cape Town.
1887. §Jacobson, Nathaniel, J.P. Olive Mount, Cheetham Hill-road, Manchester.
1905. *Jaffé, Arthur, B.A. Strandtown, Belfast.
1874. *Jaffé, John. Villa Jaffé, 38 Promenade des Anglais, Nice, France.
1905. ‡Jagger, J. W. St. George's-street, Cape Town.
1906. ‡Jalland, W. H. Museum-street, York.
1891. *James, Charles Henry, J.P. 64 Park-place, Cardiff.
1891. *James, Charles Russell. 13 Hampstead Hill-gardens, N.W.
1904. ‡James, Thomas Campbell. University College, Aberystwyth.
1905. ‡Jameson, Adam. Office of the Commissioner of Lands, Pretoria.
1896. *Jameson, H. Lyster, M.A., Ph.D. Altriston, Ewell, Surrey.
1881. ‡Jamieson, Professor Andrew, M.Inst.C.E., F.R.S.E. 16 Rosslyn-terrace, Kelvinside, Glasgow.
1859. *Jamieson, Thomas F., LL.D., F.G.S. Ellon, Aberdeenshire.
1889. *JAPP, F. R., M.A., Ph.D., LL.D., F.R.S. (Pres. B, 1898), Professor of Chemistry in the University of Aberdeen.
1910. *Japp, Henry, M.Inst.C.E. Care of Messrs. S. Pearson & Son, 507 Fifth Avenue, New York, U.S.A.
1896. *Jarmay, Gustav. Hartford Lodge, Hartford, Cheshire.
1903. ‡JARRATT, J. ERNEST (Local Sec. 1903). 10 Cambridge-road, Southport.
1904. *Jeans, J. H., M.A., F.R.S. Woodlands, Chaucer-road, Cambridge.
1897. ‡Jeffrey, E. C., B.A. The University, Toronto, Canada.
1908. *Jenkin, Arthur Pearse, F.R.Met.Soc. Trewirgie, Redruth.
1909. *Jenkins, Miss Emily Vaughan. Lyceum Club, 128 Piccadilly, W.
1903. ‡Jenkinson, J. W. The Museum, Oxford.
1904. ‡Jenkinson, W. W. 6 Moorgate-street, E.C.
1893. §Jennings, G. E. 60 Fosse-road South, Leicester.
1905. ‡Jennings, Sydney. P.O. Box 149, Johannesburg.
1905. ‡Jerome, Charles. P.O. Box 83, Johannesburg.
Jessop, William. Overton Hall, Ashover, Chesterfield.
1900. *Jevons, H. Stanley, M.A., B.Sc. Woodhill, Rhiwbeina, near Cardiff.
1907. *Jevons, Miss H. W. 19 Chesterford-gardens, Hampstead, N.W.
1905. §Jeyes, Miss Gertrude, B.A. Berrymead, 6 Lichfield-road, Kew Gardens.
1905. ‡Jobson, J. B. P.O. Box 3341, Johannesburg.
1909. *Johns, Cosmo, F.G.S., M.I.M.E. Burngrove, Pitsmoor-road, Sheffield.
1884. ‡JOHNSON, ALEXANDER, M.A., LL.D. 5 Prince of Wales-terrace, Montreal, Canada.
1909. ‡Johnson, C. Kelsall, F.R.G.S. The Glen, Sidmouth, Devon.

Year of Election.

1865. *Johnson, G. J. 36 Waterloo-street, Birmingham.

1890. *JOHNSON, THOMAS, D.Sc., F.L.S., Professor of Botany in the Royal College of Science, Dublin.

1902. *Johnson, Rev. W., B.A., B.Sc. Archbishop Holgate's Grammar School, York.

1898. *Johnson, W. Claude, M.Inst.C.E. Broadstone, Coleman's Hatch, Sussex.

1899. ‡JOHNSTON, Colonel Sir DUNCAN A., K.C.M.G., C.B., R.E., Hon. Sec. R.G.S. (Pres. E, 1909.) Branksome, Saffrons-road, Eastbourne.

1883. ‡*JOHNSTON, Sir H. H., G.C.M.G., K.C.B., F.R.G.S. 27 Chester-terrace, Regent's Park, N.W.*

1909. *Johnston, J. Weir, M.A. 10 Lower Fitzwilliam-street, Dublin.

1908. ‡Johnston, Swift Paine. 1 Hume-street, Dublin.

1884. *Johnston, W. H. County Offices, Preston, Lancashire.

1885. ‡JOHNSTON-LAVIS, H. J., M.D., F.G.S. Beaulieu, Alpes-Maritimes, France.

1909. §Jolly, Professor W. A., M.B., D.Sc. South African College, Cape Town.

1888. ‡JOLY, JOHN, M.A., D.Sc., F.R.S., F.G.S. (Pres. C, 1908), Professor of Geology and Mineralogy in the University of Dublin. Geological Department, Trinity College, Dublin.

1904. §Jones, Miss E. E. Constance. Girton College, Cambridge.

1890. §JONES, Rev. EDWARD, F.G.S. Primrose Cottage, Embsay, Skipton.

1896. ‡Jones, E. Taylor, D.Sc. University College, Bangor.

1903. §Jones, Evan. Ty-Mawr, Aberdare.

1907. *Jones, Mrs. Evan. 12 Hyde Park-gate, S.W.

1887. ‡Jones, Francis, F.R.S.E., F.C.S. Beaufort House, Alexandra Park, Manchester.

1891. *JONES, Rev. G. HARTWELL, D.D. Nutfield Rectory, Redhill, Surrey.

1883. *Jones, George Oliver, M.A. Inchyra House, 21 Cambridge-road, Waterloo, Liverpool.

1903. *JONES, H. O., M.A. Clare College, Cambridge.

1905. ‡Jones, Miss Parnell. The Rectory, Llanddewi Skirrid, Abergavenny, Monmouthshire.

1901. ‡Jones, R. E., J.P. Oakley Grange, Shrewsbury.

1902. ‡Jones, R. M., M.A. Royal Academical Institution, Belfast.

1908. ‡Jones, R. Pugh, M.A. County School, Holyhead, Anglesey.

1875. *Jose, J. E. Ethersall, Tarbock-road, Huyton, Lancashire.

1872. ‡Joy, Algernon. Junior United Service Club, St. James's, S.W.

1883. ‡Joyce, Rev. A. G., B.A. St. John's Croft, Winchester.

1886. ‡Joyce, Hon. Mrs. St. John's Croft, Winchester.

1905. ‡Judd, Miss Hilda M., B.Sc. Berrymead, 6 Lichfield-road, Kew.

1870. ‡JUDD, JOHN WESLEY, C.B., LL.D., F.R.S., F.G.S. (Pres. C, 1885; Council, 1886–92.) Orford Lodge, 30 Cumberland-road, Kew.

1903. §JULIAN, HENRY FORBES. Redholme, Braddon's Hill-road, Torquay.

1894. §Julian, Mrs. Forbes. Redholme, Braddon's Hill-road, Torquay.

1905. §Juritz, Charles F., M.A., D.Sc., F.I.C., Chief of the Division of Chemistry, Union of South Africa. Department of Agriculture, Cape Town.

1888. ‡Kapp, Gisbert, M.Inst.C.E., M.Inst.E.E. Pen-y-Coed, Pritchatts-road, Birmingham.

1904. ‡Kayser, Professor H. The University, Bonn, Germany.

Year of Election.

1892. ‡KEANE, CHARLES A., Ph.D. Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C.

1908. §Keeble, Frederick, M.A., Sc.D., Professor of Botany in University College, Reading.

1911. *Keith, Arthur, F.R.C.S. Royal College of Surgeons, Lincoln's Inn-fields, W.C.

1884. ‡Kellogg, J. H., M.D. Battle Creek, Michigan, U.S.A.

1908. ‡Kelly, Malachy. Ard Brugh, Dalkey, Co. Dublin.

1908. ‡Kelly, Captain Vincent Joseph. Montrose, Donnybrook, Co. Dublin.

1911. §Kelly, Miss. Montrose, Merton-road, Southsea.

1902. *Kelly, William J., J.P. 25 Oxford-street, Belfast.

1885. §KELTIE, J. SCOTT, LL.D., Sec. R.G.S., F.S.S. (Pres. E, 1897; Council, 1898-1904.) 1 Savile-row, W.

1877. *Kelvin, Lady. Netherhall, Largs, Ayrshire; and 15 Eaton-place, S.W.

1887. ‡Kemp, Harry. 55 Wilbraham-road, Chorlton-cum-Hardy, Manchester.

1898. *Kemp, John T., M.A. 4 Cotham-grove, Bristol.

1884. ‡Kemper, Andrew C., A.M., M.D. 101 Broadway, Cincinnati, U.S.A.

1891. ‡KENDALL, PERCY F., M.Sc., F.G.S., Professor of Geology in the University of Leeds.

1875. ‡KENNEDY, Sir ALEXANDER B. W., LL.D., F.R.S. M.Inst.C.E. (Pres. G, 1894.) 1 Queen Anne-street, Cavendish-square, W.

1897. §Kennedy, George, M.A., LL.D., K.C. Crown Lands Department, Toronto, Canada.

1906 ‡Kennedy, Robert Sinclair. Glengall Ironworks, Millwall, E.

1908. ‡Kennedy, William. 40 Trinity College, Dublin.

1905. *Kennerley, W. R. P.O. Box 158, Pretoria.

1893. §KENT, A. F. STANLEY, M.A., F.L.S., F.G.S., Professor of Physiology in the University of Bristol.

1901. ‡Kent, G. 16 Premier-road, Nottingham.

1857. *Ker, André Allen Murray. Newbliss House, Newbliss, Ireland.

1909. †Kerr, Hugh L. 68 Admiral-road, Toronto, Canada.

1892. ‡KERR, J. GRAHAM, M.A., F.R.S., Regius Professor of Zoology in the University of Glasgow.

1889. ‡Kerry, W. H. R. The Sycamores, Windermere.

1910. §Kershaw, J. B. C. West Lancashire Laboratory, Waterloo, Liverpool.

1869. *Kesselmeyer, Charles Augustus. Roseville, Vale-road, Bowdon, Cheshire.

1869. *Kesselmeyer, William Johannes. Edelweiss Villa, Albert-road, Hale, Cheshire.

1903. ‡Kewley, James. Balek Papan, Koltei, Dutch Borneo.

1883. *Keynes, J. N., M.A., D.Sc., F.S.S. 6 Harvey-road, Cambridge.

1905. ‡Kidd, Professor A. Stanley. Rhodes University College, Grahamstown, Cape Colony.

1902. ‡Kidd, George. Greenhaven, Malone Park, Belfast.

1906. ‡Kidner, Henry, F.G.S. 25 Upper Rock-gardens, Brighton.

1886. §KIDSTON, ROBERT, LL.D., F.R.S., F.R.S.E., F.G.S. 12 Clarendon-place, Stirling.

1901. *Kiep, J. N. 137 West George-street, Glasgow.

1885. *Kilgour, Alexander. Loirston House, Cove, near Aberdeen.

1896. *Killey, George Deane, J.P. Bentuther, 11 Victoria-road, Waterloo, Liverpool.

1890. ‡KIMMINS, C. W., M.A., D.Sc. Dame Armstrong House, Harrow.

1875. *KINCH, EDWARD, F.I.C., Professor of Chemistry in the Royal Agricultural College, Cirencester.

Year of
Election.
1875. *King, F. Ambrose. Avonside, Clifton, Bristol.
1871. *King, Rev. Herbert Poole. The Rectory, Stourton, Bath.
1883. *King, John Godwin. Stonelands, East Grinstead.
1883. *King, Joseph, M.P. Sandhouse, Witley, Godalming.
1908. §King, Professor L. A. L., M.A. St. Mungo's College Medical School, Glasgow.
1860. *King, Mervyn Kersteman. Merchants' Hall, Bristol.
1875. *King, Percy L. 2 Worcester-avenue, Clifton, Bristol.
1870. ‡King, William, M.Inst.C.E. 5 Beach-lawn, Waterloo, Liverpool.
1909. ‡Kingdon, A. 197 Yale-avenue, Winnipeg, Canada.
1903. §Kingsford, H. S., M.A. 60 Clapton-common, N.E.
1900. ‡KIPPING, Professor F. STANLEY, D.Sc., Ph.D., F.R.S. (Pres. B, 1908.) University College, Nottingham.
1899. *Kirby, Miss C. F. 8 Windsor-court, Moscow-road, W.
1907. §Kirby, William Forsell, F.L.S. Hilden, 46 Sutton Court-road, Chiswick, W.
1905. ‡Kirkby, Reginald G. P.O. Box 7, Pietermaritzburg, Natal.
1901. §Kitto, Edward. The Observatory, Falmouth.
1886. ‡Knight, Captain J. M., F.G.S. Bushwood, Wanstead, Essex.
1905. ‡Knightley, Lady, of Fawsley. Fawsley Park, Daventry.
1888. ‡KNOTT, Professor CARGILL G., D.Sc., F.R.S.E. 42 Upper Gray-street, Edinburgh.
1887. *Knott, Herbert, J.P. Sunnybank, Wilmslow, Cheshire.
1887. *Knott, John F. Nant-y-Coed, Conway, North Wales.
1906. *Knowles, Arthur J., B.A., M.Inst.C.E. Turf Club, Cairo, Egypt.
1874. ‡Knowles, William James. Flixton-place, Ballymena, Co. Antrim.
1902. ‡KNOX, R. KYLE, LL.D. 1 College-gardens, Belfast.
1875. *Knubley, Rev. E. P., M.A. Steeple Ashton Vicarage, Trowbridge.
1883. ‡Knubley, Mrs. Steeple Ashton Vicarage, Trowbridge.
1905. ‡Koenig, J. P.O. Box 272, Cape Town.
1890. *Krauss, John Samuel, B.A. Stonycroft, Knutsford-road, Wilmslow, Cheshire.
1888 *Kunz, G. F., M.A., Ph.D. Care of Messrs. Tiffany & Co., 11 Union-square, New York City, U.S.A.

1905. ‡Lacey, William. Champ d'Or Gold Mining Co., Luipaardsvlei, Transvaal.
1903. *Lafontaine, Rev. H. C. de. 49 Albert-court, Kensington Gore, S.W.
1909. ‡Laird, Hon. David. Indian Commission, Ottawa, Canada.
1904. ‡Lake, Philip. St. John's College, Cambridge.
1904. ‡Lamb, C. G. Ely Villa, Glisson-road, Cambridge.
1880. *Lamb, Edmund, M.A. Borden Wood, Liphook, Hants.
1887. ‡LAMB, HORACE, M.A., LL.D., D.Sc., F.R.S. (Pres. A, 1904), Professor of Pure Mathematics in the Victoria University, Manchester. 6 Wilbraham-road, Fallowfield, Manchester.
1909. ‡*Lamb, J. R. 389 Graham-avenue, Winnipeg, Canada.*
1903. ‡Lambert, Joseph. 9 Westmoreland-road, Southport.
1893. *LAMPLUGH, G. W., F.R.S., F.G.S. (Pres. C, 1906.) 13 Beaconsfield-road, St. Albans.
1905. ‡Lane, Rev. C. A. P.O. Box 326, Johannesburg.
1898. *LANG, WILLIAM H., F.R.S. 2 Heaton-road, Withington, Manchester.
1905. ‡*Lange, John H. Judges' Chambers, Kimberley.*
1886. *LANGLEY, J. N., M.A., D.Sc., F.R.S. (Pres. I, 1899; Council, 1904–07), Professor of Physiology in the University of Cambridge. Trinity College, Cambridge.

Year of Election.

1865. ‡LANKESTER, Sir E. RAY, K.C.B., M.A., LL.D., D.Sc., F.R.S. (PRESIDENT, 1906; Pres. D, 1883; Council, 1889–90, 1894–95, 1900–02.) 29 Thurloe-place, S.W.

1880. *LANSDELL, Rev. HENRY, D.D., F.R.A.S., F.R.G.S. Morden College, Blackheath, London, S.E.

1884. ‡Lanza, Professor G. Massachusetts Institute of Technology, Boston, U.S.A.

1911. §Lapthorn, Miss. St. Bernards, Grove-road South, Southsea.

1885. ‡LAPWORTH, CHARLES, LL.D., F.R.S., F.G.S. (Pres. C, 1892), Professor of Geology and Physiography in the University of Birmingham. 48 Frederick-road, Edgbaston, Birmingham.

1909. §Larard, C. E., A.M.Inst.C.E. 106 Cranley-gardens, Muswell Hill, N.

1887. ‡Larmor, Alexander. Craglands, Helen's Bay, Co. Down.

1881. ‡LARMOR, Sir JOSEPH, M.A., D.Sc., Sec.R.S. (Pres. A, 1900), Lucasian Professor of Mathematics in the University of Cambridge. St. John's College, Cambridge.

1883. ‡Lascelles, B. P., M.A. Headland, Mount Park, Harrow.

1870. *LATHAM, BALDWIN, M.Inst.C.E., F.G.S. Parliament-mansions, Westminster, S.W.

1911. §Lattey, R. T. Royal Naval College, Dartmouth.

1900. ‡Lauder, Alexander, Lecturer in Agricultural Chemistry in the Edinburgh and East of Scotland College of Agriculture, Edinburgh.

1911. §Laurie, Miss C. L. 1 Vittoria-walk, Cheltenham.

1892. ‡LAURIE, MALCOLM, B.A., D.Sc., F.L.S. School of Medicine, Surgeons' Hall, Edinburgh.

1883. ‡Laurie, Lieut.-General. 47 Porchester-terrace, W.

1907. *Laurie, Robert Douglas. Department of Zoology, The University, Liverpool.

1870. *Law, Channell. Ilsham Dene, Torquay.

1905. ‡Lawrence, Miss M. Roedean School, near Brighton.

1911. *Lawson, A. Anstruther, D.Sc., F.R.S.E., F.L.S. The University, Glasgow.

1908. §Lawson, H. S., B.A. Harben, Compton-road, Wolverhampton.

1908. ‡Lawson, William, LL.D. 27 Upper Fitzwilliam-street, Dublin.

1888. ‡Layard, Miss Nina F., F.L.S. Rookwood, Fonnereau-road, Ipswich.

1883. *Leach, Charles Catterall. Seghill, Northumberland.

1894. *LEAHY, A. H., M.A., Professor of Mathematics in the University of Sheffield. 92 Ashdell-road, Sheffield.

1905. ‡Leake, E. O. 5 Harrison-street, Johannesburg.

1901. *Lean, George, B.Sc. 15 Park-terrace, Glasgow.

1904. *Leathem, J. G. St. John's College, Cambridge.

1884. *Leavitt, Erasmus Darwin. 2 Central-square, Cambridgeport, Massachusetts, U.S.A.

1872. ‡LEBOUR, G. A., M.A., D.Sc., Professor of Geology in the Armstrong College of Science, Newcastle-on-Tyne.

1910. §Lebour, Miss M. V., M.Sc. Zoological Department, The University, Leeds.

1895. *Ledger, Rev. Edmund. Protea, Doods-road, Reigate.

1907. ‡Lee, Mrs. Barton. 126 Mile End-lane, Stockport.

1910. *Lee, Ernest. 2 Claughton-street, Burnley, Lancashire.

1896. §Lee, Rev. H. J. Barton. 126 Mile End-lane, Stockport.

1909. §Lee, I. L. Care of Messrs. Harris, Winthrop, & Co., 24 Throgmorton-street, E.C.

1909. §Lee, Rev. J. W., D.D. 5068 Washington-avenue, St. Louis, Missouri, U.S.A.

1894. *Lee, Mrs. W. Ashdown House, Forest Row, Sussex.

Year of Election.

1884. *Leech, Sir Bosdin T. Oak Mount, Timperley, Cheshire.

1909. ‡Leeming, J. H., M.D. 406 Devon-court, Winnipeg, Canada.

1905. §Lees, Mrs. A. P. Care of Dr. Norris Wolfenden, 76 Wimpole-street, W.

1892. *LEES, CHARLES H., D.Sc., F.R.S., Professor of Physics in the East London College, Mile End. Greenacres, Woodside-road, Woodford Green, Essex.

1886. *Lees, Lawrence W. Old Ivy House, Tettenhall, Wolverhampton.

1906. ‡Lees, Robert. Victoria-street, Fraserburgh.

1905. ‡Lees, R. Wilfrid. Pigg's Peak Development Co., Swaziland, South Africa.

1889. *Leeson, John Rudd, M.D., C.M., F.L.S., F.G.S. Clifden House, Twickenham, Middlesex.

1906. ‡Leetham, Sidney. Elm Bank, York.

1905. ‡Legg, W. A. P.O. Box 1621, Cape Town.

1911. §LEGGATT, W. G. (LOCAL TREASURER, 1912.) Bank of Scotland, Dundee.

1912. §Legge, James G., Municipal Buildings, Liverpool.

1910. §Leigh, H. S. Brentwood, Worsley, near Manchester.

1891. ‡Leigh, W. W. Glyn Bargood, Treharris, R.S.O., Glamorganshire.

1903. ‡Leighton, G. R., M.D., F.R.S.E., Professor of Pathology in the Royal Veterinary College, Edinburgh.

1906. ‡Leiper, Robert T., M.B., F.Z.S. London School of Tropical Medicine, Royal Albert Dock, E.

1905. ‡Leitch, Donald. P.O. Box 1703, Johannesburg.

1882. §Lemon, Sir James, M.Inst.C.E., F.G.S. 11 The Avenue, Southampton.

1903. *Lempfert, R. G. K., M.A. 66 Sydney-street, S.W.

1908. ‡Lentaigne, John. 42 Merrion-square, Dublin.

1887. *Leon, John T. Elmwood, Grove-road, Southsea.

1901. §LEONARD, J. H., B.Sc. 13 Gunterstone-road, West Kensington, W.

1905. ‡Leonard, Right Rev. Bishop John. St. Mary's, Cape Town.

1890. *Lester, Joseph Henry. 5 Grange-drive, Monton Green, Manchester.

1904. *Le Sueur, H. R., D.Sc. Chemical Laboratory, St Thomas's Hospital, S.E.

1900. ‡Letts, Professor E. A., D.Sc., F.R.S.E. Queen's College, Belfast.

1896. ‡Lever, Sir W. H., Bart. Thornton Manor, Thornton Hough, Cheshire.

1905. ‡Levin, Benjamin. P.O. Box 74, Cape Town.

1887. *Levinstein, Ivan. Hawkesmoor, Fallowfield, Manchester.

1893. *LEWES, VIVIAN B., F.C.S., Professor of Chemistry in the Royal Naval College, Greenwich, S.E.

1905. ‡Lewin, J. B. Duncan's-chambers, Shortmarket-street, Cape Town.

1904. *Lewis, Mrs. Agnes S., LL.D. Castle Brae, Chesterton-lane, Cambridge.

1870 ‡LEWIS, ALFRED LIONEL. 35 Beddington-gardens, Wallington, Surrey.

1891. ‡Lewis, Professor D. Morgan, M.A. University College, Aberystwyth.

1899. ‡Lewis, Professor E. P. University of California, Berkeley, U.S.A.

1905. ‡Lewis, F. S., M.A. South African Public Library, Cape Town.

1910. §LEWIS, FRANCIS J., D.Sc., F.L.S. The University, Liverpool.

1904. ‡Lewis, Hugh. Glanafrau, Newtown, Montgomeryshire.

1910. *Lewis, T. C. West Home, West-road, Cambridge.

1911. §Lewis, W. Garnoyle, Bangor, Co. Down.

1903. ‡Lewkowitsch, Dr. J. 71 Priory-road, N.W.

1906. ‡Liddiard, James Edward, F.R.G.S. Rodborough Grange, Bournemouth.

Year of Election.

1908. ‡Lilly, W. E., M.A., Sc.D. 39 Trinity College, Dublin.
1904. ‡Link, Charles W. 14 Chichester-road, Croydon.
1898. §Lippincott, R. C. Cann. Over Court, near Bristol.
1895. *LISTER, The Right Hon. Lord, O.M., F.R.C.S., D.C.L., D.Sc., F.R.S. (PRESIDENT, 1896.) 12 Park-crescent, Portland-place, W.
1888. ‡LISTER, J. J., M.A., F.R.S. (Pres. D, 1906.) St. John's College, Cambridge.
1861. *LIVEING, G. D., M.A., F.R.S. (Pres. B, 1882; Council 1888-95; Local Sec. 1862.) Newnham, Cambridge.
1876. *LIVERSIDGE, ARCHIBALD, M.A., F.R.S., F.C.S., F.G.S., F.R.G.S. Hornton Cottage, Hornton-street, Kensington, W.
1902. §Llewellyn, Evan. Working Men's Institute and Hall, Blaenavon.
1909. §Lloyd, George C., Secretary of the Iron and Steel Institute. 28 Victoria-street, S.W.
1903. ‡Lloyd, Godfrey I. H. The University of Toronto, Canada.
1854. *LOBLEY, J. LOGAN, F.G.S., F.R.G.S. 36 Palace-street, Buckingham Gate, S.W.
1892. ‡LOCH, C. S., D.C.L. Denison House, Vauxhall Bridge-road, S.W.
1905. ‡Lochrane, Miss T. 8 Prince's-gardens, Dowanhill, Glasgow.
1904. ‡Lock, Rev. J. B. Herschel House, Cambridge.
1863. †LOCKYER, Sir J. NORMAN, K.C.B., LL.D., D.Sc., F.R.S. (PRESIDENT, 1903; Council, 1871-76, 1901-02.) 16 Penywern-road, S.W.
1902. *Lockyer, Lady. 16 Penywern-road, S.W.
1900. §LOCKYER, W. J. S., Ph.D. 16 Penywern-road, S.W.
1886. *LODGE, ALFRED, M.A. The Croft, Peperharow-road, Godalming
1875. *LODGE, Sir OLIVER J., D.Sc., LL.D., F.R.S. (Pres. A, 1891; Council, 1891-97, 1899-1903), Principal of the University of Birmingham.
1894. **Lodge, Oliver W. F. 17 Ruskin-buildings, Westminster, S.W.*
1899. §Loncq, Emile. 6 Rue de la Plaine, Laon, Aisne, France.
1902. ‡LONDONDERRY, The Marquess of, K.G. Londonderry House, Park-lane, W.
1903. †Long, Frederick. The Close, Norwich.
1905. ‡Long, W. F. City Engineer's Office, Cape Town.
1883. *Long, William. Thelwall Heys, near Warrington.
1910. *Londgen, G. A. Pleasley, Mansfield.
1904. *Longden, J. A., M.Inst.C.E. Stanton-by-Dale, Nottingham.
1905. ‡Longden, Mrs. J. B. Stanton-by-Dale, Nottingham.
1898. *Longfield, Miss Gertrude. Belmont, High Halstow, Rochester.
1901. *Longstaff, Frederick V., F.R.G.S. Ridgelands, Wimbledon, Surrey.
1875. *Longstaff, George Blundell, M.A., M.D., F.C.S., F.S.S. Highlands, Putney Heath, S.W.
1872. *Longstaff, Llewellyn Wood, F.R.G.S. Ridgelands, Wimbledon, S.W.
1881. *Longstaff, Mrs. Ll. W. Ridgelands, Wimbledon, S.W.
1899. *Longstaff, Tom G., M.A., M.D. Ridgelands, Wimbledon, S.W.
1903. ‡Loton, John, M.A. 23 Hawkshead-street, Southport.
1897. ‡LOUDON, JAMES, LL.D., President of the University of Toronto, Canada.
1883. *LOUIS, D. A., F.G.S., F.I.C. 123 Pall Mall, S.W.
1896. §Louis, Henry, D.Sc., Professor of Mining in the Armstrong College of Science, Newcastle-on-Tyne.
1887. *LOVE, A. E. H., M.A., D.Sc., F.R.S. (Pres. A, 1907), Professor of Natural Philosophy in the University of Oxford. 34 St. Margaret's-road, Oxford.
1886. *Love, E. F. J., M.A., D.Sc. The University, Melbourne, Australia.
1904. *Love, J. B. Outlands, Devonport.
1876. *Love, James, F.R.A.S., F.G.S., F.Z.S. 33 Clanricarde-gardens, W.

Year of
Election.

1905. ‡Loveday, Professor T. South African College, Cape Town.
1908. §Low, Alexander, M.A., M.B. The University, Aberdeen.
1900. ‡Low, David, M.D. 1927 Scarth-street, Regina, Saskatchewan, Canada.
1885. §Lowdell, Sydney Poole. Baldwin's Hill, East Grinstead, Sussex.
1891. §Lowdon, John. St. Hilda's, Barry, Glamorgan.
1885. *Lowe, Arthur C. W. Gosfield Hall, Halstead, Essex.
1905. ‡Lowe, E. C. Chamber of Trade, Johannesburg.
1886. *Lowe, John Landor, B.Sc., M.Inst.C.E. Spondon, Derbyshire.
1894. ‡Lowenthal, Miss Nellie. Woodside, Egerton, Huddersfield.
1903. *LOWRY, Dr. T. MARTIN. 130 Horseferry-road, S.W.
1901. *Lucas, Keith. Trinity College, Cambridge.
1891. *Lucovich, Count A. Tyn-y-parc, Whitchurch, near Cardiff.
1906. §Ludlam, Ernest Bowman. College Gate, 32 College-road, Clifton, Bristol.
1866. *Lund, Charles. Ilkley, Yorkshire.
1850. *Lundie, Cornelius. 32 Newport-road, Cardiff.
1905. ‡Lunnon, F. J. P.O. Box 400, Pretoria.
1883. *Lupton, Arnold, M.P., M.Inst.C.E., F.G.S. 7 Victoria-street, S.W.
1874. *LUPTON, SYDNEY, M.A. (Local Sec. 1890.) 102 Park-street, Grosvenor-square, W.
1898. §Luxmoore, Dr. C. M., F.I.C., 19 Disraeli-gardens, Putney, S.W.
1903. ‡Lyddon, Ernest H. Lisvane, near Cardiff.
1884 ‡Lyman, H. H. 384 St. Paul-street, Montreal, Canada.
1907. *Lyons, Captain Henry George, D.Sc., F.R.S. 5 Heathview-gardens, Roehampton, S.W.
1908. ‡Lyster, George H. 34 Dawson-street, Dublin.
1908. ‡Lyster, Thomas W., M.A. National Library of Ireland, Kildare-street, Dublin.

1905. ‡Maberly, Dr. John. Shirley House, Woodstock, Cape Colony.
1868. ‡MACALISTER, ALEXANDER, M.A., M.D., F.R.S. (Pres. H, 1892; Council, 1901–06), Professor of Anatomy in the University of Cambridge. Torrisdale, Cambridge.
1878. ‡MACALISTER, Sir DONALD, K.C.B., M.A., M.D., LL.D., B.Sc., Principal of the University of Glasgow.
1904. ‡Macalister, Miss M. A. M. Torrisdale, Cambridge.
1908. ‡Macallan, J., F.I.C., F.R.S.E. 3 Rutland-terrace, Clontarf, Co. Dublin.
1896. ‡MACALLUM, Professor A. B., Ph.D., D.Sc., F.R.S. (Pres. I, 1910; Local Sec. 1897.) 59 St. George-street, Toronto, Canada.
1879. §MacAndrew, James J., F.L.S. Lukesland, Ivybridge, South Devon.
1883. ‡MacAndrew, Mrs. J. J. Lukesland, Ivybridge, South Devon.
1909. ‡MacArthur, J. A., M.D. Canada Life Building, Winnipeg, Canada.
1896. *Macaulay, F. S., M.A. 19 Dewhurst-road, W.
1904. *Macaulay, W. H. King's College, Cambridge.
1896. ‡MACBRIDE, Professor E. W., M.A., D.Sc., F.R.S. Imperial College of Science and Technology, S.W.
1902. *Maccall, W. T., M.Sc. Technical College, Sunderland.
1886. ‡MacCarthy, Rev. E. F. M., M.A. 50 Harborne-road, Edgbaston, Birmingham.
1908. §McCarthy, Edward Valentine, J.P. Ardmanagh House, Glenbrook, Co. Cork.
1909. ‡McCarthy, J. H. Public Library, Winnipeg, Canada.
1884. *McCarthy, J. J., M.D. 11 Wellington-road, Dublin.
1887. *McCarthy, James. 1 Sydney-place, Bath.
1904. ‡McClean, Frank Kennedy. Rusthall House, Tunbridge Wells.

Year of Election.

1902. ‡McClelland, J. A., M.A., F.R.S., Professor of Physics in University College, Dublin.

1906. ‡McClure, Rev. E. 80 Eccleston-square, S.W.

1878. *M'Comas, Henry. 12 Elgin-road, Dublin.

1908. §McCombie, Hamilton, M.A., Ph.D. The University, Birmingham.

1901. *MacConkey, Alfred. Queensberry Lodge, Elstree, Herts.

1905. ‡McConnell, D. E. Montrose-avenue, Orangezicht, Cape Town.

1901. ‡MacCormac, J. M., M.D. 31 Victoria-place, Belfast.

1901. ‡McCrae, John, Ph.D. 7 Kirklee-gardens, Glasgow.

1905. §McCulloch, Principal J. D. Free College, Edinburgh.

1904. ‡McCulloch, Major T., R.A. 68 Victoria-street, S.W.

1909. ‡MacDonald, Miss Eleanor. Fort Qu'Appelle, Saskatchewan, Canada.

1904. ‡MACDONALD, H. M., M.A., F.R.S., Professor of Mathematics in the University of Aberdeen.

1905. ‡McDonald, J. G. P.O. Box 67, Bulawayo.

1900. ‡MacDonald, J. Ramsay, M.P. 3 Lincoln's Inn-fields, W.C.

1905. §MACDONALD, J. S., B.A. (Pres. I, 1911), Professor of Physiology in the University of Sheffield.

1884. *Macdonald, Sir W. C. 449 Sherbrooke-street West, Montreal, Canada.

1909. ‡MacDonell, John, M.D. Portage-avenue, Winnipeg, Canada.

1909. *MacDougall, R. Stewart. The University, Edinburgh.

1912. §McDougall, Dr. W. Woodsend, Foxcombe Hill, near Oxford.

1908. ‡McEwen, Walter, J.P. Flowerbank, Newton Stewart, Scotland.

1897. ‡McEwen, William C. 9 South Charlotte-street, Edinburgh.

1881. ‡Macfarlane, Alexander, D.Sc., F.R.S.E. 317 Victoria-avenue, Chatham, Ontario, Canada.

1906. §McFarlane, John, M.A. 30 Parsonage-road, Withington, Manchester.

1885. ‡Macfarlane, J. M., D.Sc., F.R.S.E., Professor of Biology in the University of Pennsylvania, Lansdowne, Delaware Co., Pennsylvania, U.S.A.

1905. ‡Macfarlane, T. J. M. P.O. Box 1198, Johannesburg.

1901. ‡Macfee, John. 5 Greenlaw-terrace, Paisley.

1909. ‡Macgachen, A. F. D. 281 River-avenue, Winnipeg, Canada.

1888. ‡MacGeorge, James. 8 Matheson-road, Kensington, W.

1908. ‡McGRATH, Sir JOSEPH, LL.D. (Local Sec. 1908.) Royal University of Ireland, Dublin.

1908. §MacGregor, Charles. Training Centre, Charlotte-street, Aberdeen.

1906. ‡MACGREGOR, D. H., M.A. Trinity College, Cambridge.

1884. *MACGREGOR, JAMES GORDON, M.A., D.Sc., F.R.S., F.R.S.E., Professor of Natural Philosophy in the University of Edinburgh.

1902. ‡McIlroy, Archibald. Glenvale, Drumbo, Lisburn, Ireland.

1905. ‡Macindoe, Flowerdue. 23 Saratoga-avenue, Johannesburg.

1867. *McINTOSH, W. C., M.D., LL.D., F.R.S., F.R.S.E., F.L.S. (Pres. D, 1885), Professor of Natural History in the University of St. Andrews. 2 Abbotsford-crescent, St. Andrews, N.B.

1909. ‡McIntyre, Alexander. 142 Maryland-avenue, Winnipeg, Canada.

1909. ‡McIntyre, Daniel. School Board Offices, Winnipeg, Canada.

1909. ‡McIntyre, W. A. 339 Kennedy-street, Winnipeg, Canada.

1884. §MacKay, A. H., B.Sc., LL.D., Superintendent of Education. Education Office, Halifax, Nova Scotia, Canada.

1885. ‡MACKAY, JOHN YULE, M.D., LL.D., Principal of and Professor of Anatomy in University College, Dundee.

1908. ‡McKay, William, J.P. Clifford-chambers, York.

1909. §McKee, Dr. E. S. Grand and Nassau-streets, Cincinnati, U.S.A.

1873. ‡McKENDRICK, JOHN G., M.D., LL.D., F.R.S., F.R.S.E. (Pres. I, 1901; Council, 1903-09), Emeritus Professor of Physiology in the University of Glasgow. Maxieburn, Stonehaven, N.B.

Year of Election.

1909. ‡McKenty, D. E. 104 Colony-street, Winnipeg, Canada.
1905. ‡McKenzie, A. R. P.O. Box 214, Cape Town.
1905. ‡Mackenzie, Hector. Standard Bank of South Africa, Cape Town.
1897. ‡McKenzie, John J. 61 Madison-avenue, Toronto, Canada.
1910. ‡Mackenzie, K. J. J., M.A. 10 Richmond-road, Cambridge.
1909. §MacKenzie, Kenneth. Royal Alexandra Hotel, Winnipeg, Canada.
1901. *Mackenzie, Thomas Brown. Netherby, Manse-road, Motherwell, N.B.
1872. *Mackey, J. A. United University Club, Pall Mall East, S.W.
1901. ‡Mackie, William, M.D. 13 North-street, Elgin.
1887. ‡MACKINDER, H. J., M.A., M.P., F.R.G.S. (Pres. E, 1895; Council, 1904-1905.) 243 St. James's-court, Buckingham-gate, S.W.
1911. §Mackinnon, Miss D. L. 302 Blackness-road, Dundee.
1893. *McLaren, Mrs. E. L. Colby, M.B., Ch.B. 133 Tettenhall-road, Wolverhampton.
1901. ‡Maclaren, J. Malcolm. Royal Colonial Institute, Northumberland Avenue, W.C.
1905. ‡McLaren, Thomas. P.O. Box 1034, Johannesburg.
1901. ‡Maclay, William. Thornwood, Langside, Glasgow.
1901. ‡McLean, Angus, B.Sc. Harvale, Meikleriggs, Paisley.
1892. *MACLEAN, MAGNUS, M.A., D.Sc., F.R.S.E. (Local Sec. 1901), Professor of Electrical Engineering, Technical College, Glasgow.
1909. ‡MacLean, Neil Bruce. 24 Hitchcock Hall, The University, Chicago, U.S.A.
1908. ‡McLennan, J. C., Professor of Physics in the University of Toronto, Canada.
1868. §MCLEOD, HERBERT, F.R.S. (Pres. B, 1892; Council, 1885-90.) 37 Montague-road, Richmond, Surrey.
1909. ‡MacLeod, M. H. C.N.R. Depôt, Winnipeg, Canada.
1883. ‡MACMAHON, Major PERCY A., R.A., D.Sc., F.R.S. (GENERAL SECRETARY, 1902- ; Pres. A, 1901; Council, 1898-1902.) 27 Evelyn-mansions, Carlisle-place, S.W.
1909. ‡MCMILLAN, The Hon. Sir DANIEL H., K.C.M.G. Government House, Winnipeg, Canada.
1902. ‡McMordie, Robert J. Cabin Hill, Knock, Co. Down.
1905. ‡MacNay, Arthur. Cape Government Railway Offices, De Aar, Cape Colony.
1878. ‡Macnie, George. 59 Bolton-street, Dublin.
1905. §Macphail, Dr. S. Rutherford. Rowditch, Derby.
1909. ‡MacPhail, W. M. P.O. Box 88, Winnipeg, Canada.
1905. ‡Macrae, Harold J. P.O. Box 817, Johannesburg.
1907. ‡Macrosty, Henry W. 29 Hervey-road, Blackheath, S.E.
1906. ‡Macturk, G. W. B. 15 Bowlalley-lane, Hull.
1908. ‡McVittie, R. B., M.D. 62 Fitzwilliam-square North, Dublin.
1908. ‡McWalter, J. C., M.D., M.A. 19 North Earl-street, Dublin.
1902. ‡McWeeney, Professor E. J., M.D. 84 St. Stephen's-green, Dublin.
1910. §McWilliam, Andrew, Professor of Metallurgy in the University of Sheffield.
1908. ‡MADDEN, Rt. Hon. Mr. Justice. Nutley, Booterstown, Dublin.
1905. ‡Magenis, Lady Louisa. 34 Lennox-gardens, S.W.
1909. ‡Magnus, Laurie, M.A. 12 Westbourne-terrace, W.
1875. *MAGNUS, Sir PHILIP, B.Sc., B.A., M.P. (Pres. L, 1907). 16 Gloucester-terrace, Hyde Park, W.
1908. *Magson, Egbert H. Westminster College, Horseferry-road, S.W.
1907. *Mair, David. Civil Service Commission, Burlington-gardens, W.
1908. *Makower, W. The University, Manchester.

Year of Election.

1857. ‡MALLET, JOHN WILLIAM, Ph.D., M.D., F.R.S., F.C.S., Professor of Chemistry in the University of Virginia, Albemarle Co., U.S.A.

1905. ‡Maltby, Lieutenant G R., R.N. 54 St. George's-square, S.W.

1897. ‡MANCE, Sir H. C. Old Woodbury, Sandy, Bedfordshire.

1903. ‡Manifold, C. C. 16 St. James's-square, S.W.

1905. ‡Manning, D. W., F.R.G.S. Roydon, Rosebank, Cape Town.

1894. ‡Manning, Percy, M.A., F.S.A. Watford, Herts.

1887. *March, Henry Colley, M.D., F.S.A. Portesham, Dorchester, Dorsetshire.

1902. *MARCHANT, Dr. E. W. The University, Liverpool.

1898. *Mardon, Heber. 2 Litfield-place, Clifton, Bristol.

1911. *Marett, R. R. Exeter College, Oxford.

1900. ‡Margerison, Samuel. Calverley Lodge, near Leeds.

1864. ‡MARKHAM, Sir CLEMENTS R., K.C.B., F.R.S., F.R.G.S., F.S.A. (Pres. E. 1879; Council, 1893-96.) 21 Eccleston-square, S.W.

1905. §Marks, Samuel. P.O. Box 379, Pretoria.

1905. ‡Marloth, R., M.A., Ph.D. P.O. Box 359, Cape Town.

1881. *MARR, J. E., M.A., D.Sc., F.R.S., F.G.S. (Pres. C, 1896; Council, 1896-1902, 1910- .) St. John's College, Cambridge.

1903. ‡Marriott, William. Royal Meteorological Society, 70 Victoria-street, S.W.

1892. *Marsden-Smedley, J. B. Lea Green, Cromford, Derbyshire.

1883. *Marsh, Henry Carpenter. 3 Lower James-street, Golden-square, W.

1887. ‡Marsh, J. E., M.A., F.R.S. University Museum, Oxford.

1889. *MARSHALL, ALFRED, M.A., LL.D., D.Sc. (Pres. F, 1890.) Balliol Croft, Madingley-road, Cambridge.

1904. ‡Marshall, F. H. A. University of Edinburgh.

1905. §Marshall, G. A. K. 6 Chester-place, Hyde Park-square, W.

1892. §MARSHALL, HUGH, D.Sc., F.R.S., F.R.S.E., Professor of Chemistry in University College, Dundee.

1901. ‡Marshall, Robert. 97 Wellington-street, Glasgow.

1886. *MARSHALL, WILLIAM BAYLEY, M.Inst.C.E. Imperial Hotel, Malvern.

1907. ‡Marston, Robert. 14 Ashleigh-road, Leicester.

1899. §Martin, Miss A. M. Park View, 32 Bayham-road, Sevenoaks.

1911. §MARTIN, CHARLES JAMES, M.B., D.Sc., F.R.S. Lister Institute, Chelsea-gardens, S.W.

1905. ‡Martin, John. P.O. Box 217, Germiston, Transvaal.

1884. §Martin, N. H., J.P., F.R.S.E., F.L.S. Ravenswood, Low Fell, Gateshead.

1889. *Martin, Thomas Henry, Assoc.M.Inst.C.E. Windermere, Mount Pleasant-road, Hastings.

1912. §MARTIN, W. H. BLYTH. (LOCAL SECRETARY, 1912.) City Chambers, Dundee.

1911. §Martindell, E. W., M.A. Royal Anthropological Institute, 50 Great Russell-street, W.C.

1905 ‡Marwick, J. S. P.O. Box 1166. Johannesburg.

1905. ‡Marx, Mrs. Charles. Shabana, Robinson-street, Belgravia, South Africa.

1907. ‡Masefield, J. R. B., M.A. Rosehill, Cheadle, Staffordshire.

1905. *Mason, Justice A. W. Supreme Court, Pretoria.

1893. *Mason, Thomas. Enderleigh, Alexandra Park, Nottingham.

1891. *Massey, William H., M.Inst.C.E. Twyford, R.S.O., Berkshire.

1885. ‡Masson, David Orme, D.Sc., F.R.S., Professor of Chemistry in the University of Melbourne.

1910. §Masson, Irvine, M.Sc. 11 Chester-street, Edinburgh.

1905. §Massy, Miss Mary. 3 Carlton-place, Teignmouth, Devon.

Year of Election.

1901. *Mather, G. R. Boxlea, Wellingborough.

1910. *Mather, Thomas, F.R.S., Professor of Electrical Engineering in the City and Guilds of London Institute, Exhibition-road, S.W.

1887. *Mather, Right Hon. Sir William, M.Inst.C.E. Salford Iron Works, Manchester.

1909. ‡Mathers, Mr. Justice. 16 Edmonton-street, Winnipeg, Canada.

1908. ‡Matheson, Sir R. E., LL.D. Charlemont House, Rutland-square, Dublin.

1905. ‡Mathew, Alfred Harfield. P.O. Box 242, Cape Town.

1894. ‡MATHEWS, G. B., M.A., F.R.S. 10 Menai View, Bangor, North Wales.

1902. ‡Matley, C. A., D.Sc. Morningside, Egmont-road, Sutton, Surrey.

1904. ‡Matthews, D. J. The Laboratory, Citadel Hill, Plymouth.

1905. ‡Matthews, J. Wright, M.D. P.O. Box 437, Johannesburg.

1911. §Matthey, George, F.R.S. Cheyne House, Chelsea Embankment, S.W.

1899. *Maufe, Herbert, B., B.A., F.G.S. P.O. Box 168, Bulawayo, Rhodesia.

1893. ‡Mavor, Professor James. University of Toronto, Canada.

1865. *MAW, GEORGE, F.L.S., F.G.S., F.S.A. Benthall, Kenley, Surrey.

1894. §Maxim, Sir Hiram S. Thurlow Park, Norwood-road, West Norwood, S.E.

1905. §Maylard, A. Ernest. 12 Blythswood-square, Glasgow.

1905. ‡Maylard, Mrs. 12 Blythswood-square, Glasgow.

1878. *Mayne, Thomas. 19 Lord Edward-street, Dublin.

1904. ‡Mayo, Rev. J., LL.D. 6 Warkworth-terrace, Cambridge.

1905. ‡Mearns, J. Herbert, M.D. Edenville, 10 Oxford-road, Observatory, Cape Town.

1879. §Meiklejohn, John W. S., M.D. 105 Holland-road, W.

1905. ‡Mein, W. W. P.O. Box 1145, Johannesburg.

1881. *MELDOLA, RAPHAEL, D.Sc., LL.D., F.R.S., F.C.S., F.I.C., F.R.A.S., F.E.S., Officier de l'Instr. Publ. France (Pres. B, 1895; Council, 1892 99, 1911-), Professor of Chemistry in the Finsbury Technical College, City and Guilds of London Institute. 6 Brunswick-square, W.C.

1908. ‡Meldrum, A. N., D.Sc. Chemical Department, The University, Manchester.

1883. ‡Mellis, Rev. James. 23 Part-street, Southport.

1879. *Mellish, Henry. Hodsock Priory, Worksop.

1866. ‡MELLO, Rev. J. M., M.A., F.G.S. Cliff Hill, Warwick.

1881. §Melrose, James. Clifton Croft, York.

1905. *Melvill, E. H. V., F.G.S., F.R.G.S. P.O. Val, Standerton District, Transvaal.

1909. ‡Menzies, Rev. James, M.D. Hwaichingfu, Honan, China.

1905. ‡Meredith, H. O., M.A., Professor of Economics in Queen's University, Belfast.

1908. ‡MEREDITH, Sir JAMES CREED, LL.D. Royal University of Ireland, Dublin.

1879. ‡MERIVALE, JOHN HERMAN, M.A. (Local Sec. 1889.) Togston Hall, Acklington.

1899. *Merrett, William H., F.I.C. Hatherley, Grosvenor-road, Wallington, Surrey.

1905. ‡Merriman, Right Hon. John X. Schoongezicht, Stellenbosch, Cape Colony.

1899. ‡Merryweather, J. C. 4 Whitehall-court, S.W.

1884. *Merthyr, The Right Hon. Lord, K.C.V.O. The Mardy, Aberdare.

1889. *Merz, John Theodore. The Quarries, Newcastle-upon-Tyne.

1905. ‡Methven, Cathcart W. Club Arcade, Smith-street, Durban.

Year of Election.

1896. §Metzler, W. H., Ph.D., Professor of Mathematics in Syracuse University, Syracuse, New York, U.S.A.

1869. ‡MIALL, LOUIS C., D.Sc., F.R.S., F.L.S., F.G.S. (Pres. D, 1897; Pres. L, 1908; Local Sec. 1890.) Norton Way North, Letchworth.

1903. *Micklethwait, Miss Frances M. G. 15 St. Mary's-square, Paddington, W.

1881. *Middlesbrough, The Right Rev. Richard Lacy, D.D., Bishop of. Bishop's House, Middlesbrough.

1904. ‡Middleton, T. H., M.A. South House, Barton-road, Cambridge.

1894. *MIERS, Sir H. A., M.A., D.Sc., F.R.S., F.G.S. (Pres. C, 1905; Pres. L, 1910), Principal of the University of London. 23 Wetherby-gardens, S.W.

1885. §MILL, HUGH ROBERT, D.Sc., LL.D., F.R.S.E., F.R.G.S. (Pres. E, 1901.) 62 Camden-square, N.W.

1905. ‡Mill, Mrs. H. R. 62 Camden-square, N.W.

1911. §MILLAR, Dr. A. H. (LOCAL SECRETARY, 1912.) Dundee.

1889. *MILLAR, ROBERT COCKBURN. 30 York-place, Edinburgh.

Millar, Thomas, M.A., LL.D., F.R.S.E. Perth.

1909. §Miller, A. P. Vermilion Bay, Ontario, Canada.

1895. ‡Miller, Thomas, M.Inst.C.E. 9 Thoroughfare, Ipswich.

1909. ‡Miller, Professor W. G. Bureau of Mines, Toronto, Canada.

1904. ‡Millis, C. T. Hollydene, Wimbledon Park-road, Wimbledon.

1905. §Mills, Mrs. A. A. Ceylon Villa, Blinco-grove, Cambridge.

1908. ‡Mills, Miss E. A. Nurney, Glenagarey, Co. Dublin.

1868. *MILLS, EDMUND J., D.Sc., F.R.S., F.C.S. 64 Twyford-avenue, West Acton, W.

1908. §Mills, Miss Gertrude Isabel. Nurney, Glenagarey, Co. Dublin.

1908. §Mills, John Arthur, M.B. Durham County Asylum, Winterton, Ferryhill.

1908. §Mills, W. H., M.Inst.C.E. Nurney, Glenagarey, Co. Dublin.

1902. ‡Mills, W. Sloan, M.A. Vine Cottage, Donaghmore, Newry.

1907. ‡Milne, A., M.A. University School, Hastings.

1910. §Milne, J. B. Cross Grove House, Totley, near Sheffield.

1910. *Milne, James Robert, D.Sc., F.R.S.E. 11 Melville-crescent, Edinburgh.

1882. *MILNE, JOHN, D.Sc., F.R.S., F.G.S. Shide, Newport, Isle of Wight.

1903. *Milne, R. M. Royal Naval College, Dartmouth, South Devon.

1898. *Milner, S. Roslington, D.Sc. The University, Sheffield.

1908. §Milroy, T. H., M.D., Dunville Professor of Physiology in Queen's College, Belfast.

1907. §Milton, J. H., F.G.S. Harrison House, Crosby, Liverpool.

1880. ‡MINCHIN, G. M., M.A., F.R.S. 149 Banbury-road, Oxford.

1901. *Mitchell, Andrew Acworth. 7 Huntly-gardens, Glasgow.

1901. *Mitchell, G. A. 5 West Regent-street, Glasgow.

1909. ‡Mitchell, J. F. 211 Rupert-street, Winnipeg, Canada.

1905. ‡Mitchell, John. Government School House, Jeppestown, Transvaal.

1885. ‡MITCHELL, P. CHALMERS, M.A., D.Sc., F.R.S., Sec.Z.S. (Council, 1906– .) Zoological Society, Regent's Park, N.W.

1908. ‡Mitchell, W. M. 2 St. Stephen's Green, Dublin.

1905. *Mitchell, W. E. C. Box 129, Johannesburg.

1895. *Moat, William, M.A. Johnson Hall, Eccleshall, Staffordshire.

1908. ‡Moffat, C. B. 36 Hardwicke-street, Dublin.

1905. ‡Moir, James, D.Sc. Mines Department, Johannesburg.

1905. ‡Moir, Dr. W. Ironside. Care of Dr. McAulay, Cleveland, Transvaal.

1905. ‡Molengraaff, Professor G. A. F. The Technical University of Delft, The Hague.

Year of Election.

1883. ‡Mollison, W. L., M.A. Clare College, Cambridge.
1900. *MONCKTON, H. W., Treas. L.S., F.G.S. 3 Harcourt-buildings, Temple, E.C.
1905. *MONCRIEFF, Colonel Sir C. SCOTT, G.C.S.I., K.C.M.G., R.E. (Pres. G, 1905.) 11 Cheyne-walk, S.W.
1905. ‡Moncrieff, Lady Scott. 11 Cheyne-walk, S.W.
1891. *Mond, Robert Ludwig, M.A., F.R.S.E., F.G.S. 20 Avenue-road, Regent's Park, N.W.
1909. §Moody, A. W., M.D. 432½ Main-street, Winnipeg, Canada.
1909. §MOODY, G. T., D.Sc. Lorne House, Dulwich, S.E.
1908. *Moore, F. W. Royal Botanic Gardens, Glasnevin, Dublin.
1891. ‡Moore, Harold E. Oaklands, The Avenue, Beckenham, Kent.
1908. ‡Moore, Sir John W., M.D. 40 Fitzwilliam-square West, Dublin.
1901. *Moore, Robert T. 142 St. Vincent-street, Glasgow.
1905. ‡Moore, T. H. Thornhill Villa, Marsh, Huddersfield.
1896. *Mordey, W. M. 82 Victoria-street, S.W.
1901. *Moreno, Francisco P. Paraná 915, Buenos Aires.
1905. *Morgan, Miss Annie. Friedrichstrasse No. 2, Vienna.
1895. ‡MORGAN, C. LLOYD, F.R.S., F.G.S., Professor of Psychology in the University of Bristol.
1902. ‡MORGAN, GILBERT T., D.Sc., F.I.C. Imperial College of Science and Technology, S.W
1902. *Morgan, Septimus Vaughan. 37 Harrington-gardens, S.W.
1901. *Morison, James. Perth.
1883. *MORLEY, HENRY FORSTER, M.A., D.Sc., F.C.S. 5 Lyndhurst-road, Hampstead, N.W.
1906. ‡Morrell, H. R. Scarcroft-road, York.
1896. ‡Morrell, Dr. R.S. Tor Lodge, Tettenhall Wood, Wolverhampton.
1892. ‡MORRIS, Sir DANIEL, K.C.M.G., D.Sc., F.L.S. 14 Crabton-close, Boscombe, Hants.
1908. ‡Morris, E. A. Montmorency, M.A., M.R.I.A. Winton House, Cabra, Co. Dublin.
1905. ‡Morris, F., M.B., B.Sc. 18 Hope-street, Cape Town.
1896. *Morris, J. T. 47 Cumberland-mansions, Seymour-place, W.
1880. §Morris, James. 6 Windsor-street, Uplands, Swansea.
1907. ‡Morris, Colonel Sir W. G., K.C.M.G. Care of Messrs. Cox & Co., 16 Charing Cross, W.C.
1899. *MORROW, JOHN, M.Sc., D.Eng. Armstrong College, Newcastle-upon-Tyne.
1909. ‡Morse, Morton F. Wellington-crescent, Winnipeg, Canada.
1865. ‡Mortimer, J. R. St. John's Villas, Driffield.
1886. *Morton, P. F. 15 Ashley-place, Westminster, S.W.
1896. *MORTON, WILLIAM B., M.A., Professor of Natural Philosophy in Queen's University, Belfast.
1908. ‡Moss, Dr. C. E. Botany School, Cambridge.
1876. §MOSS, RICHARD JACKSON, F.I.C., M.R.I.A. Royal Dublin Society, and St. Aubyn's, Ballybrack, Co. Dublin.
1892. *Mostyn, S. G., M.A., M.B. Health Office, Houndgate, Darlington.
1878. *MOULTON, The Right Hon. Lord Justice, M.A., K.C., F.R.S. 57 Onslow-square, S.W.
1899 §Mowll, Martyn. Chaldercot, Leyburne-road, Dover.
1905. ‡Moylan, Miss V. C. 3 Canning-place, Palace Gate, W.
1905. *Moysey, Miss E. L. Pitcroft, Guildford, Surrey.
1911. *Moysey, Lewis, B.A., M.B. St. Moritz, Ilkeston-road, Nottingham.
1902. §Muir, Arthur H. 2 Wellington-place, Belfast.
1907. *Muir, Professor James. 31 Burnbank-gardens, Glasgow.
1874. ‡MUIR, M. M. PATTISON, M.A. Hillcrest, Farnham, Surrey.

Year of Election.
1909. ‡Muir, Robert R. Grain Exchange-building, Winnipeg, Canada.
1904. §Muir, William, I.S.O. Rowallan, Newton Stewart, N.B.
1872. *MUIRHEAD, ALEXANDER, D.Sc., F.R.S., F.C.S. 12 Carteret-street, Queen Anne's Gate, Westminster, S.W.
1905. *Muirhead, James M. P., F.R.S.E. Markham's-chambers, St. George's-street, Cape Town.
1876. *Muirhead, Robert Franklin, B.A., D.Sc. 64 Great George-street, Hillhead, Glasgow.
1902. ‡Mullan, James. Castlerock, Co. Derry.
1884. *MÜLLER, HUGO, Ph.D., F.R.S., F.C.S. 13 Park-square East, Regent's Park, N.W.
1905. ‡Mulligan, A. 'Natal Mercury' Office, Durban, Natal.
1908. ‡MULLIGAN, JOHN. (Local Sec. 1908.) Greinan, Adelaide-road, Kingstown, Co. Dublin.
1904. §Mullinger, J. Bass, M.A. 1 Bene't-place, Cambridge.
1911. §Mumby, Dr. B. H. Borough Asylum, Milton, Portsmouth.
1898. ‡Mumford, C. E. Cross Roads House, Bouverie-road, Folkestone.
1901. *Munby, Alan E. 44 Downshire-hill, Hampstead, N.W.
1906. ‡Munby, Frederick J. Whixley, York.
1904. ‡Munro, A. Queens' College, Cambridge.
1909. ‡Munro, George. 188 Roslyn-road, Winnipeg, Canada.
1883. *MUNRO, ROBERT, M.A., M.D., LL.D. (Pres. H, 1893.) Elmbank, Largs, Ayrshire, N.B.
1909. ‡Munson, J. H., K.C. Wellington-crescent, Winnipeg, Canada.
1911. §Murdoch, W. H. F., B.Sc. 14 Howitt-road, Hampstead, N.W.
1909. §Murphy, A. J. Vanguard Manufacturing Co., Dorrington-street, Leeds.
1908. ‡Murphy, Leonard. 156 Richmond-road, Dublin.
1908. ‡MURPHY, WILLIAM M., J.P. Dartry, Dublin.
1905 ‡Murray, Charles F. K., M.D. Kenilworth House, Kenilworth, Cape Colony.
1905. ‡Murray, Dr. F. Londinium, London-road, Sea Point, Cape Town.
1905. §Murray, Sir James, LL.D., Litt.D. Sunnyside, Oxford.
1905. §Murray, Lady. Sunnyside, Oxford.
1884. ‡MURRAY, Sir JOHN, K.C.B., LL.D., D.Sc., Ph.D., F.R.S., F.R.S.E. (Pres. E, 1899.) Challenger Lodge, Wardie, Edinburgh.
1903. §Murray, Colonel J. D. Rowbottom-square, Wigan.
1909. ‡Murray, W. C. University of Saskatchewan, Saskatoon, Saskatchewan, Canada.
1870. *Muspratt, Edward Knowles. Seaforth Hall, near Liverpool.
1906. ‡Myddelton-Gavey, E. H., M.R.C.S., J.P. Stanton Prior, Meads, Eastbourne.
1902. ‡Myddleton, Alfred. 62 Duncairn-street, Belfast.
1902. *Myers, Charles S., M.A., M.D. Great Shelford, Cambridge.
1909. *Myers, Henry. The Long House, Leatherhead.
1906. ‡Myers, Jesse A. Glengarth, Walker-road, Harrogate.
1890. *MYRES, JOHN L., M.A., F.S.A. (Pres. H, 1909; Council, 1909–), Wykeham Professor of Ancient History in the University of Oxford. 101 Banbury-road, Oxford.

1886. ‡NAGEL, D. H., M.A. (Local Sec. 1894.) Trinity College, Oxford.
1892. *Nairn, Sir Michael B., Bart. Kirkcaldy, N.B.
1890. ‡Nalder, Francis Henry. 34 Queen-street, E.C.
1908. ‡Nally, T. H. Temple Hill, Terenure, Co. Dublin.

Year of Election.

1905. ‡Napier, Dr. Francis. 73 Jeppe-street, Von Brandis-square, Johannesburg.

1872. ‡NARES, Admiral Sir G. S., K.C.B., R.N., F.R.S., F.R.G.S. 7 The Crescent, Surbiton.

1909. ‡Neild, Frederic, M.D. Mount Pleasant House, Tunbridge Wells.

1883. *Neild, Theodore, M.A. Grange Court, Leominster.

1898. *Nevill, Rev. J. H. N., M.A. The Vicarage, Stoke Gabriel, South Devon.

1866. *Nevill, The Right Rev. Samuel Tarratt, D.D., F.L.S., Bishop of Dunedin, New Zealand.

1889. ‡NEVILLE, F. H., M.A., F.R.S. Sidney College, Cambridge.

1889. *NEWALL, H. FRANK, M.A., F.R.S., F.R.A.S., Professor of Astrophysics in the University of Cambridge. Madingley Rise, Cambridge.

1901. ‡Newman, F. H. Tullie House, Carlisle.

1889. ‡Newstead, A. H. L., B.A. 38 Green-street, Bethnal Green, N.E.

1892. ‡NEWTON, E. T., F.R.S., F.G.S. Florence House, Willow Bridge-road, Canonbury, N.

1908. ‡Nicholls, W. A. 11 Vernham-road, Plumstead, Kent.

1908. ‡Nichols, Albert Russell. 30 Grosvenor-square, Rathmines, Co. Dublin.

1887. ‡Nicholson, John Carr, J.P. Moorfield House, Headingley, Leeds.

1884. ‡NICHOLSON, JOSEPH S., M.A., D.Sc. (Pres. F, 1893), Professor of Political Economy in the University of Edinburgh.

1908. §Nicholson, J. W. Trinity College, Cambridge.

1911. §Nicol, J. C., M.A. The Grammar School, Portsmouth.

1908. ‡NIXON, Sir CHRISTOPHER, Bart., M.D., LL.D., D.L. 2 Merrion-square, Dublin.

1863. *NOBLE, Sir ANDREW, Bart., K.C.B., D.Sc., F.R.S., F.R.A.S., F.C.S. (Pres. G, 1890 ; Council, 1903–06 ; Local Sec. 1863.) Elswick Works, and Jesmond Dene House, Newcastle-upon-Tyne.

1863. §NORMAN, Rev. Canon ALFRED MERLE, M.A., D.C.L., LL.D., F.R.S., F.L.S. The Red House, Berkhamsted.

1888. ‡Norman, George. 12 Brock-street, Bath.

1883. *Norris, William G. Dale House, Coalbrookdale, R.S.O., Shropshire.

1894. §NOTCUTT, S. A., LL.M., B.A., B.Sc. (Local Sec. 1895.) Constitution-hill, Ipswich.

1909. ‡Nugent, F. S. 81 Notre Dame-avenue, Winnipeg, Canada.

1910. §Nunn, T. Percy, M.A., D.Sc. London Day Training College, Southampton-row, W.C.

1908. ‡Nutting, Sir John, Bart. St. Helen's, Co. Dublin.

1898. *O'Brien, Neville Forth. Fryth, Pyrford, Surrey.

1908. ‡O'Carroll, Joseph, M.D. 43 Merrion-square East, Dublin.

1883. ‡Odgers, William Blake, M.A., LL.D., K.C. 15 Old-square, Lincoln's Inn, W.C.

1910. *Odling, Marmaduke, B.A., F.G.S. 15 Norham-gardens, Oxford.

1858. *ODLING, WILLIAM, M.B., F.R.S., V.P.C.S. (Pres. B, 1864 ; Council, 1865–70), Waynflete Professor of Chemistry in the University of Oxford. 15 Norham-gardens, Oxford.

1911. *O'DONOGHUE, CHARLES H., B.Sc. University College, Gower-street, W.C.

1908. §O'Farrell, Thomas A., J.P. 30 Lansdowne-road, Dublin.

1902. ‡Ogden, James Neal. Claremont, Heaton Chapel, Stockport.

1876. ‡Ogilvie, Campbell P. Lawford-place, Manningtree.

1885. ‡OGILVIE, F. GRANT, C.B., M.A., B.Sc., F.R.S.E. (Local Sec. 1892.) Board of Education, S.W.

Year of Election

1905. *Oke, Alfred William, B.A., LL.M., F.G.S., F.L.S. 32 Denmark-villas, Hove, Brighton.

1905. §Okell, Samuel, F.R.A.S. Overley, Langham-road, Bowdon, Cheshire.

1908. §Oldham, Charles Hubert, B.A., B.L., Professor of Commerce in the National University of Ireland. 5 Victoria-terrace, Rathgar, Dublin.

1892. ‡OLDHAM, H. YULE, M.A., F.R.G.S., Lecturer in Geography in the University of Cambridge. King's College, Cambridge.

1893. *OLDHAM, R. D., F.R.S., F.G.S. 8 North-street, Horsham. Surrey.

1863. ‡OLIVER, DANIEL, LL.D., F.R.S., F.L.S., Emeritus Professor of Botany in University College, London. 10 Kew Gardens-road, Kew, Surrey.

1887. ‡OLIVER, F. W., D.Sc., F.R.S., F.L.S. (Pres. K, 1906), Professor of Botany in University College, London, W.C.

1889. ‡Oliver, Professor Sir Thomas, M.D. 7 Ellison-place, Newcastle-upon-Tyne.

1882. §OLSEN, O. T., D.Sc., F.L.S., F.R.A.S., F.R.G.S. 116 St. Andrew's-terrace, Grimsby.

1880. *Ommanney, Rev. E. A. St. Michael's and All Angels, Portsea, Hants.

1908. ‡O'Neill, Rev. G., M.A. University College, St. Stephen's Green, Dublin.

1902. ‡O'Neill, Henry, M.D. 6 College-square East, Belfast.

1902. ‡O'Reilly, Patrick Joseph. 7 North Earl-street, Dublin.

1905. ‡O'Riley, J. C. 70 Barnet-street, Gardens, Cape Town.

1884. *Orpen, Rev. T. H., M.A. The Vicarage, Great Shelford, Cambridge.

1901. ‡Orr, Alexander Stewart. 10 Medows-street, Bombay, India.

1905. ‡Orr, Professor John. Transvaal Technical Institute, Johannesburg.

1909. ‡Orr, John B. Crossacres, Woolton, Liverpool.

1908. *Orr, William. Dungarvan, Co. Waterford.

1904. *ORTON, K. J. P., M.A., Ph.D., Professor of Chemistry in University College, Bangor.

1905. ‡Osborn, Philip B. P.O. Box 4181, Johannesburg.

1910. §Osborn, T. G. B., B.Sc. The University, Manchester.

1901. ‡Osborne, W. A., D.Sc. University College, W.C.

1908. ‡O'Shaughnessy, T. L. 64 Fitzwilliam-square, Dublin.

1887. ‡O'Shea, L. T., B.Sc. University College, Sheffield.

1865. *Osler, Henry F. Coppy-hill, Linthurst, near Bromsgrove, Birmingham.

1884. ‡OSLER, Sir WILLIAM, Bart., M.D., LL.D., F.R.S., Regius Professor of Medicine in the University of Oxford. 13 Norham-gardens, Oxford.

1881. *Ottewell, Alfred D. 14 Mill Hill-road, Derby.

1896. ‡Oulton, W. Hillside, Gateacre, Liverpool.

1906. ‡Owen, Rev. E. C. St. Peter's School, York.

1903. *Owen, Edwin, M.A. Terra Nova School, Birkdale, Lancashire.

1896. ‡Owen, Peter. The Elms, Capenhurst, Chester.

1911. §Owens, J. S., M.D., Assoc.M.Inst.C.E. 47 Victoria-street, S.W.

1910. *Oxley, A. E. Rose Hill View, Kimberworth-road, Rotherham.

1909. ‡Pace, F. W. 388 Wellington-crescent, Winnipeg, Canada.

1908. ‡Pack-Beresford, Denis, M.R.I.A. Fenagh House, Bagenalstown, Ireland.

1906. §Page, Carl D. Wyoming House, Aylesbury, Bucks.

1903. *Page, Miss Ellen Iva. Turret House, Felpham, Sussex.

1883. †Page, G. W. Bank House, Fakenham.

Year of Election.

1911. §Paget, Stephen, M.A., F.R.C.S. 21 Ladbroke-square, W.

1911. §Paine, H. Howard. 50 Stow-hill, Newport, Monmouthshire.

1870. *PALGRAVE, Sir ROBERT HARRY INGLIS, F.R.S., F.S.S. (Pres. F, 1883.) Henstead Hall, Wrentham, Suffolk.

1896. ‡Pallis, Alexander. Tatoi, Aigburth-drive, Liverpool.

1878. *Palmer, Joseph Edward. Royal Societies Club, St. James's-street, S.W.

1866. §Palmer, William. Waverley House, Waverley-street, Nottingham.

1880. *Parke, George Henry, F.L.S., F.G.S. Care of W. T. Cooper, Esq., Aysgarth, The Mall, Southgate, N.

1904. ‡PARKER, E. H., M.A. Thorneycreek, Herschel-road, Cambridge.

1905. ‡Parker, Hugh. P.O. Box 200, Pietermaritzburg, Natal.

1905. ‡Parker, John. 37 Hout-street, Cape Town.

1909. §PARKER, M. A., B.Sc., F.C.S. (Local Sec. 1909), Professor of Chemistry in the University of Manitoba, Winnipeg, Canada.

1891. ‡PARKER, WILLIAM NEWTON, Ph.D., F.Z.S., Professor of Biology in University College, Cardiff.

1905. *Parkes, Tom E. P.O. Box 4580, Johannesburg.

1899. *Parkin, John. Blaithwaite, Carlisle.

1905. *Parkin, Thomas. Blaithwaite, Carlisle.

1906. §Parkin, Thomas, M.A., F.L.S., F.Z.S., F.R.G.S. Fairseat, High Wickham, Hastings.

1879. *Parkin, William. The Mount, Sheffield.

1911. §Parks, Dr. G. J. 18 Cavendish-road, Southsea.

1903. §Parry, Joseph, M.Inst.C.E. Woodbury, Waterloo, near Liverpool.

1908. ‡Parry, W. K., M.Inst.C.E. 6 Charlemont-terrace, Kingstown, Dublin.

1878. ‡PARSONS, Hon. Sir C. A., K.C.B., M.A., Sc.D., F.R.S., M.Inst.C.E. (Pres. G, 1904.) Holeyn Hall, Wylam-on-Tyne.

1904. ‡Parsons, Professor F. G. St. Thomas's Hospital, S.E.

1905. *Parsons, Hon. Geoffrey L. Northern Counties Club, Newcastle-on-Tyne.

1898. *Partridge, Miss Josephine M. 15 Grosvenor-crescent, S.W.

1887. ‡PATERSON, A. M., M.D., Professor of Anatomy in the University of Liverpool.

1908. ‡Paterson, M., LL.D. 7 Halton-place, Edinburgh.

1909. ‡Paterson, William. Ottawa, Canada.

1897. ‡Paton, D. Noel, M.D. Physiological Laboratory, The University, Glasgow.

1883. *Paton, Rev. Henry, M.A. Airtnoch, 184 Mayfield-road, Edinburgh.

1884. *Paton, Hugh. Box 2400, Montreal, Canada.

1908. §PATTEN, C. J., M.A., M.D., Sc.D. The University, Sheffield.

1874. ‡Patterson, W. H., M.R.I.A. 26 High-street, Belfast

1879. *Patzer, F. R. Clayton Lodge, Newcastle, Staffordshire.

1883. ‡Paul, George. 32 Harlow Moor-drive, Harrogate.

1887. *Paxman, James. Standard Iron Works, Colchester.

1887. *Payne, Miss Edith Annie. Hatchlands, Cuckfield, Hayward's Heath.

1877. *Payne, J. C. Charles, J.P. 4 Ulsterville-avenue, Belfast.

1881. ‡Payne, Mrs. 4 Ulsterville-avenue, Belfast.

1888. *Paynter, J. B. Hendford Manor, Yeovil.

1876. ‡Peace, G. H., M.Inst.C.E. Monton Grange, Eccles, near Manchester.

1906. ‡Peace, Miss Gertrude. 39 Westbourne-road, Sheffield.

1885. ‡PEACH, B. N., F.R.S., F.R.S.E., F.G.S. Geological Survey Office, George-square, Edinburgh.

1911. §Peake, Harold J. E. Westbrook House, Newbury.

1886. *Pearce, Mrs. Horace. Collingwood, Manby-road, West Malvern.

Year of Election.

1905. ‡Pearse, S. P.O. Box 149, Johannesburg.
1883. ‡Pearson, Arthur A., C.M.G. Hillsborough, Heath-road, Petersfield, Hampshire.
1893. *Pearson, Charles E. Hillcrest, Lowdham, Nottinghamshire.
1898. †Pearson, George. Bank-chambers, Baldwin-street, Bristol.
1905. §Pearson, Professor H. H. W., M.A., F.L.S. South African College, Cape Town.
1883. ‡Pearson, Miss Helen E. Oakhurst, Birkdale, Southport.
1906. ‡Pearson, Joseph. The University, Liverpool.
1904. ‡Pearson, Karl, M.A., F.R.S., Professor of Applied Mathematics in University College, London, W.C.
1909. §Pearson, William. Wellington-crescent, Winnipeg, Canada.
Peckitt, Henry. Carlton Husthwaite, Thirsk, Yorkshire.
1855. *PECKOVER, Lord, LL.D., F.S.A., F.L.S., F.R.G.S. Bank House, Wisbech, Cambridgeshire.
1888. ‡Peckover, Miss Alexandrina. Bank House, Wisbech, Cambridgeshire.
1885. ‡Peddie, William, Ph.D., F.R.S.E., Professor of Natural Philosophy in University College, Dundee.
1884. ‡Peebles, W. E. 9 North Frederick-street, Dublin.
1878. *Peek, William. 4 Carlyle-mansions, Brunswick-place, Hove.
1901. *Peel, Hon. William, M.P. 13 King's Bench-walk, Temple, E.C.
1905. §Peirson, J. Waldie. P.O. Box 561, Johannesburg.
1905. ‡Pemberton, Gustavus M. P.O. Box 93, Johannesburg.
1887. ‡PENDLEBURY, WILLIAM H., M.A., F.C.S. (Local Sec. 1899.) Woodford House, Mountfields, Shrewsbury.
1894. ‡Pengelly, Miss. Lamorna, Torquay.
1896. ‡Pennant, P. P. Nantlys, St. Asaph.
1898. ‡Percival, Francis W., M.A., F.R.G.S. 1 Chesham-street, S.W.
1908. ‡Percival, Professor John, M.A. University College, Reading.
1905. ‡Péringuey, L., D.Sc., F.Z.S. South African Museum, Cape Town.
1894. ‡PERKIN, A. G., F.R.S., F.R.S.E., F.C.S., F.I.C. 8 Montpelier-terrace, Hyde Park, Leeds.
1902. *Perkin, F. Mollwo, Ph.D. The Firs, Hengrave-road, Honor Oak Park, S.E.
1884. ‡PERKIN, WILLIAM HENRY, LL.D., Ph.D., F.R.S., F.R.S.E. (Pres. B, 1900; Council, 1901–07), Professor of Organic Chemistry in the Victoria University, Manchester. Fairview, Wilbraham-road, Fallowfield, Manchester.
1864. *Perkins, V. R. Wotton-under-Edge, Gloucestershire.
1898. *Perman, E. P., D.Sc. University College, Cardiff.
1909. ‡Perry, Rev. Professor E. Guthrie. 246 Kennedy-street, Winnipeg, Canada.
1874. *PERRY, JOHN, M.E., D.Sc., LL.D., F.R.S. (GENERAL TREASURER, 1904– ; Pres. G, 1902; Council, 1901–04), Professor of Mechanics and Mathematics in the Imperial College of Science and Technology, S.W.
1904. *Pertz, Miss D. F. M. 2 Cranmer-road, Cambridge.
1900. *PETAVEL, J. E., M.Sc., F.R.S., Professor of Engineering in the University of Manchester.
1901. ‡Pethybridge, G. H., Ph.D. Royal College of Science, Dublin.
1910. *Petrescu, Lieutenant Dimitrie, R.A., B.Eng. Care of Popp, Corabia, Roumania.
1895. ‡PETRIE, W. M. FLINDERS, D.C.L., F.R.S. (Pres. H, 1895), Professor of Egyptology in University College, W.C.
1871. *Peyton, John E. H., F.R.A.S., F.G.S. Vale House, St. Helier's, Jersey.

Year of Election

1863. *PHENÉ, JOHN SAMUEL, LL.D., F.S.A., F.G.S., F.R.G.S. 5 Carlton-terrace, Oakley-street, S.W. 14A Campden Hill Court, W.
1911. §Philip, Alexander. Union Bank Buildings, Brechin.
1903. ‡Philip, James C. 20 Westfield-terrace, Aberdeen.
1905. ‡Philip, John W. P.O. Box 215, Johannesburg.
1853. *Philips, Rev. Edward. Hollington, Uttoxeter, Staffordshire.
1877. §Philips, T. Wishart. Elizabeth Lodge, Crescent-road, South Woodford, Essex.
1905. ‡Phillimore, Miss C. M. Shiplake House, Henley-on-Thames.
1899. *Phillips, Charles E. S., F.R.S.E. Castle House, Shooter's Hill, Kent.
1894. ‡Phillips, Staff-Commander E. C. D., R.N., F.R.G.S. 14 Hargreaves-buildings, Chapel-street, Liverpool.
1910. *Phillips, P. P., Ph.D., Professor of Chemistry in the Thomason Engineering College, Rurki, United Provinces, India.
1890. ‡Phillips, R. W., M.A., D.Sc., F.L.S., Professor of Botany in University College, Bangor. 2 Snowdon-villas, Bangor.
1909. *Phillips, Richard. 15 Dogpole, Shrewsbury.
1905. ‡*Phillp, Miss M. E. de R., B.Sc. 12 Crescent-grove, Clapham, S.W.*
1883. *Pickard, Joseph William. Oatlands, Lancaster.
1901. §Pickard, Robert H., D.Sc. Billinge View, Blackburn.
1885. *PICKERING, SPENCER P. U., M.A., F.R.S. Harpenden, Herts.
1884. *Pickett, Thomas E., M.D. Maysville, Mason Co., Kentucky, U.S.A.
1907. ‡Pickles, A. R., M.A. Todmorden-road, Burnley.
1888. *Pidgeon, W. R. Lynsted Lodge, St. Edmund's-terrace, Regent's Park, N.W.
1865. ‡PIKE, L. OWEN. 10 Chester-terrace, Regent's Park, N.W.
1896. *Pilkington, A. C. Rocklands, Rainhill, Lancashire.
1905. ‡Pilling, Arnold. Royal Observatory, Cape Town.
1896. *Pilling, William. Rosario, Heene-road, West Worthing.
1905. ‡Pim, Miss Gertrude. Charleville, Blackrock, Co. Dublin.
1911. §Pink, H. R. The Mount, Fareham, Hants.
1911. §Pink, Mrs. H. R. The Mount, Fareham, Hants.
1911. §Pink, Mrs. J. E. The Homestead, Eastern-parade, Southsea.
1908. *Pio, Professor D. A. 14 Leverton-street, Kentish Town, N.W.
1908. ‡Pirrie, The Right Hon. Lord, LL.D., M.Inst.C.E. Downshire House, Belgrave-square, S.W.
1909. ‡Pitblado, Isaac, K.C. 91 Balmoral-place, Winnipeg, Canada.
1893. *PITT, WALTER, M.Inst.C.E. Lansdown Grove Lodge, Bath.
1908. §Pixell, Miss Helen L. M. St. Faith's Vicarage, Stoke Newington, N.
1900. *Platts, Walter. Morningside, Scarborough.
1911. *Plimmer, R. H. A. 3 Hall-road, N.W.
1898. §Plummer, W. E., M.A., F.R.A.S. The Observatory, Bidston, Birkenhead.
1908. ‡Plunkett, Count G. N. National Museum of Science and Art, Dublin.
1908. ‡Plunkett, Colonel G. T., C.B. Belvedere Lodge, Wimbledon, S.W.
1907. *PLUNKETT, Right Hon. Sir HORACE, K.C.V.O., M.A., F.R.S. Kilteragh, Foxrock, Co. Dublin.
1900. *Pocklington, H. Cabourn, M.A., D.Sc., F.R.S. 11 Regent Park-terrace, Leeds.
1904. ‡Pollard, William. 12 Aberdare-gardens, South Hampstead, N.W.
1908. ‡Pollok, James H., D.Sc. 6 St. James's-terrace, Clonskea, Dublin.
1906. *Pontifex, Miss Catherine E. 7 Hurlingham-court, Fulham, S.W.
1911. §Poore, Major-General F. H. 1 St. Helen's-parade, Southsea.

Year of Election.

1907. §Pope, Alfred, F.S.A. South Court, Dorchester.

1900. *Pope, W. J., M.A., F.R.S., Professor of Chemistry in the University of Cambridge.

1892. ‡Popplewell, W. C., M.Sc., Assoc.M.Inst.C.E. Bowden-lane, Marple, Cheshire.

1901. §Porter, Alfred W., B.Sc., F.R.S. 87 Parliament Hill-mansions, Lissenden-gardens, N.W.

1883. *Porter, Rev. C. T., LL.D., D.D. All Saints' Vicarage, Southport.

1905. §Porter, J. B., D.Sc., M.Inst.C.E., Professor of Mining Engineering in the McGill University, Montreal, Canada.

1905. ‡Porter, Mrs. McGill University, Montreal, Canada.

1883. ‡Potter, M. C., M.A., F.L.S., Professor of Botany in the Armstrong College, Newcastle-upon-Tyne. 13 Highbury, Newcastle-upon-Tyne.

1906. ‡Potter-Kirby, Alderman George. Clifton Lawn, York.

1907. ‡Potts, F. A. University Museum of Zoology, Cambridge.

1908. *Potts, George. Ph.D., M.Sc. Grey University College, Bloemfontein, South Africa.

1886. *Poulton, Edward B., M.A., F.R S., F.L.S., F.G.S., F.Z.S. (Pres. D, 1896; Council, 1895–1901, 1905–), Professor of Zoology in the University of Oxford. Wykeham House, Banbury-road, Oxford.

1905. ‡Poulton, Mrs. Wykeham House, Banbury-road, Oxford.

1898. *Poulton, Edward Palmer, M.A. Wykeham House, Banbury-road, Oxford.

1905. ‡Poulton, Miss. Wykeham House, Banbury-road, Oxford.

1905. ‡Poulton, Miss M. Wykeham House, Banbury-road, Oxford.

1894. *Powell, Sir Richard Douglas, Bart., M.D. 62 Wimpole-street, Cavendish-square, W.

1887. §Pownall, George H. 20 Birchin-lane, E.C.

1883. ‡Poynting, J. H., D.Sc., F.R.S. (Pres. A, 1899), Professor of Physics in the University of Birmingham. 10 Ampton-road, Edgbaston, Birmingham.

1908. ‡Praeger, R. Lloyd, B.A., M.R.I.A. Lisnamae, Rathgar, Dublin.

1907. *Prain, Lieut.-Col. David, C.I.E., C.M.G., M.B., F.R.S. (Pres. K, 1909; Council, 1907– .) Royal Gardens, Kew.

1884. *Prankerd, A. A., D.C.L. 66 Banbury-road, Oxford.

1906. ‡Pratt, Miss Edith M., D.Sc. The Woodlands, Silverdale, Lancashire.

1869. *Preece, Sir William Henry, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1888; Council, 1888–95, 1896–1902.) Gothic Lodge, Wimbledon Common, S.W.

1888. *Preece, W. Llewellyn, M.Inst.C.E. 8 Queen Anne's-gate, S.W.

1904. §Prentice, Mrs. Manning. Thelema, Undercliff-road, Felixstowe.

1892. ‡Prentice, Thomas. Willow Park, Greenock.

1910. ‡Prescott, R. M. (Local Sec., 1910.) Town Hall, Sheffield.

1906. ‡Pressly, D. L. Coney-street, York.

1889. ‡Preston, Alfred Eley, M.Inst.C.E., F.G.S. 14 The Exchange, Bradford, Yorkshire.

1903. §Price, Edward E. Oaklands, Oaklands-road, Bromley, Kent.

1888. ‡Price, L. L. F. R., M.A., F.S.S. (Pres. F, 1895; Council, 1898–1904.) Oriel College, Oxford.

1875. *Price, Rees. 163 Bath-street, Glasgow.

1897. *Price, W. A., M.A. 38 Gloucester-road, Teddington.

1908. §Priestley, J. H., B.Sc., Professor of Botany in the University of Leeds.

1909. *Prince, Professor E. E. Ottawa, Canada.

1905. ‡Prince, James Perrott, M.D. Durban, Natal.

Year of Election.

1889. *Pritchard, Eric Law, M.D., M.R.C.S. 70 Fairhazel-gardens, South Hampstead, N.W.
1876. *PRITCHARD, URBAN, M.D., F.R.C.S. 26 Wimpole-street, W.
1881. §Procter, John William. Ashcroft, York.
1884. *Proudfoot, Alexander, M.D. 100 State-street, Chicago, U.S.A.
1879. *Prouse, Oswald Milton, F.G.S. Alvington, Ilfracombe.
1872. *Pryor, M. Robert. Weston Park, Stevenage, Herts.
1867. *Pullar, Sir Robert, M.P., F.R.S.E. Tayside, Perth.
1883. *Pullar, Rufus D., F.C.S. Brahan, Perth.
1903. ‡Pullen-Burry, Miss. Lyceum Club, 128 Piccadilly, W.
1904. ‡Punnett, R. C., M.A., Professor of Biology in the University of Cambridge. Caius College, Cambridge.
1905. ‡Purcell, W. F., M.A., Ph.D. South African Museum, Cape Town.
1905. ‡Purcell, Mrs. W. F. South African Museum, Cape Town.
1885. ‡PURDIE, THOMAS, B.Sc., Ph.D., F.R.S., Professor of Chemistry in the University of St. Andrews. 14 South-street, St. Andrews, N.B.
1881. ‡Purey-Cust, Very Rev. Arthur Percival, M.A., Dean of York. The Deanery, York.
1884. *Purves, W. Laidlaw. 20 Stratford-place, Oxford-street, W.
1911. §Purvis, J. E. Corpus Christi College, Oxford.
1860. *Pusey, S. E. B. Bouverie. Pusey House, Faringdon.
1898. *Pye, Miss E. St. Mary's Hall, Rochester.
1883. §Pye-Smith, Arnold. 32 Queen Victoria-street, E.C.
1883. ‡Pye-Smith, Mrs. 32 Queen Victoria-street, E.C.
1868. ‡PYE-SMITH, P. H., M.D., F.R.S. 48 Brook-street, W.; and Guy's Hospital, S.E.
1879. ‡Pye-Smith, R. J. 450 Glossop-road, Sheffield.
1911. §Pye-Smith, Mrs. R. J. 450 Glossop-road, Sheffield.

1893. ‡Quick, James. 22 Bouverie-road West, Folkestone.
1906. *Quiggin, Mrs. A. Hingston. 88 Hartington-grove, Cambridge.

1879. ‡Radford, R. Heber. 15 St. James's-row, Sheffield.
1855. *Radstock, The Right Hon. Lord. Mayfield, Woolston, Southampton.
1911. §Rae, John T. National Temperance League, Paternoster House, Paternoster-row, E.C.
1887. *Ragdale, John Rowland. The Beeches, Stand, near Manchester.
1905. ‡Raine, Miss. P.O. Box 788, Johannesburg.
1905. ‡Raine, Robert. P.O. Box 1091, Johannesburg.
1898. *Raisin, Miss Catherine A., D.Sc., Bedford College, York-place, Baker-street, W.
1896. *RAMAGE, HUGH, M.A. The Technical Institute, Norwich.
1894. *RAMBAUT, ARTHUR A., M.A., D.Sc., F.R.S., F.R.A.S., M.R.I.A. Radcliffe Observatory, Oxford.
1908. ‡Rambaut, Mrs. Radcliffe Observatory, Oxford.
1876. *RAMSAY, Sir WILLIAM, K.C.B., Ph.D., D.Sc., F.R.S. (PRESIDENT; Pres. B, 1897; Council, 1891–98), Professor of Chemistry in University College, London. 19 Chester-terrace, Regent's Park, N.W.
1883. ‡Ramsay, Lady. 19 Chester-terrace, Regent's Park, N.W.
1869. *Rance, H. W. Henniker, LL.D. 10 Castletown-road, W.
1907. ‡Rankine, A. O. 21 Drayton-road, West Ealing, W.
1868. *Ransom, Edwin, F.R.G.S. 24 Ashburnham-road, Bedford.
1861. ‡RANSOME, ARTHUR, M.A., M.D., F.R.S. (Local Sec. 1861.) Sunnyhurst, Dean Park, Bournemouth.

Year of Election.

1903. §Rastall, R. H. Christ's College, Cambridge.

1892. *Rathbone, Miss May. Backwood, Neston, Cheshire.

1874. ‡RAVENSTEIN, E. G., F.R.G.S., F.S.S. (Pres. E, 1891.) 2 York-mansions, Battersea Park, S.W.

1908. *Raworth, Alexander. Fairholm, Uppingham-road, Leicester.

1905. ‡Rawson, Colonel Herbert E., R.E. Army Headquarters, Pretoria.

1868. *RAYLEIGH, The Right Hon. Lord, O.M., M.A., D.C.L., LL.D., F.R.S., F.R.A.S., F.R.G.S. (PRESIDENT, 1884; TRUSTEE, 1883- ; Pres. A, 1882; Council, 1878-83), Professor of Natural Philosophy in the Royal Institution, London. Terling Place, Witham, Essex.

1883. *Rayne, Charles A., M.D., M.R.C.S. St. Mary's Gate, Lancaster.

1897. *Rayner, Edwin Hartree, M.A. 40 Gloucester-road, Teddington, Middlesex.

1907. ‡Rea, Carleton, B.C.L. 34 Foregate-street, Worcester.

1896. *READ, CHARLES H., LL.D., F.S.A. (Pres. H, 1899.) British Museum, W.C.

1902. ‡Reade, R. H. Wilmount, Dunmurry.

1884. §Readman, J. B., D.Sc., F.R.S.E. Belmont, Hereford.

1852. *REDFERN, Professor PETER, M.D. (Pres. D, 1874.) Templepatrick House, Donaghadee, Co. Down.

1890. *Redwood, Sir Boverton, Bart., D.Sc., F.R.S.E., F.C.S. Wadham Lodge, Wadham-gardens, N.W.

1908. ‡Reed, Sir Andrew, K.C.B., C.V.O., LL.D. 23 Fitzwilliam-square, Dublin.

1905. §Reed, J. Howard, F.R.G.S. 16 St. Mary's Parsonage, Manchester.

1891. *Reed, Thomas A. Bute Docks, Cardiff.

1894. *Rees, Edmund S. G. Dunscar, Oaken, near Wolverhampton.

1891. *Rees, I. Treharne, M.Inst.C.E. Blaenypant, near Newport, Monmouthshire.

1903. §Reeves, E. A., F.R.G.S. 1 Savile-row, W.

1911. §REEVES, Hon. W. PEMBER. (Pres. F. 1911.) London School of Economics, Clare Market, W.C.

1906. *Reichel, Sir H. R., LL.D., Principal of University College, Bangor. Penrallt, Bangor, North Wales.

1910. *Reid, Alfred, M.B., M.R.C.S. Kuala Lumpur, Selangor.

1901. *Reid, Andrew T. 10 Woodside-terrace, Glasgow.

1904. ‡Reid, Arthur H. 30 Welbeck-street, W.

1881. §Reid, Arthur S., M.A., F.G.S. Trinity College, Glenalmond, N.B.

1883. *REID, CLEMENT, F.R.S., F.L.S., F.G.S. 28 Jermyn-street, S.W.

1903. *Reid, Mrs. E. M., B.Sc. One Acre, Milford-on-Sea, Hampshire.

1892. ‡REID, E. WAYMOUTH, B.A., M.B., F.R.S., Professor of Physiology in University College, Dundee.

1908. §REID, GEORGE ARCHDALL, M.B., C.M., F.R.S.E. 9 Victoria-road South, Southsea.

1901. *Reid, Hugh. Belmont, Springburn, Glasgow.

1901. ‡Reid, John. 7 Park-terrace, Glasgow.

1909. ‡Reid, John Young. 329 Wellington-crescent, Winnipeg, Canada.

1904. ‡Reid, P. J. Moor Cottage, Nunthorpe, R.S.O., Yorkshire.

1897. ‡Reid, T. Whitehead, M.D. St. George's House, Canterbury.

1887. *Reid, Walter Francis. Fieldside, Addlestone, Surrey.

1875. ‡REINOLD, A. W., C.B., M.A., F.R.S. (Council, 1890-95). 9 Vanbrugh Park-road, Blackheath, S.E.

1894. ‡Rendall, Rev. G. H., M.A., Litt.D. Charterhouse, Godalming.

1891. *Rendell, Rev. James Robson, B.A. Whinside, Whalley-road, Accrington.

Year of Election.

1903. *RENDLE, Dr. A. B., M.A., F.R.S., F.L.S. 28 Holmbush-road, Putney, S.W.

1889. *Rennie, George B. 20 Lowndes-street, S.W.

1906. ‡Rennie, John, D.Sc. Natural History Department, University of Aberdeen.

1905. *Renton, James Hall. Rowfold Grange, Billingshurst, Sussex.

1905. ‡Reunert, Clive. Windybrow, Johannesburg

1905. ‡Reunert, John. Windybrow, Johannesburg.

1904. ‡REUNERT, THEODORE, M.Inst.C.E. P.O. Box 92, Johannesburg.

1905. §Reyersbach, Louis. Care of Messrs. Wernher, Beit, & Co., 1 London Wall-buildings, E.C.

1883. *Reynolds, A. H. 271 Lord-street, Southport.

1871. ‡REYNOLDS, JAMES EMERSON, M.D., D.Sc., F.R.S., F.C.S., M.R.I.A. (Pres. B, 1893; Council, 1893-99.) 3 Inverness-gardens, W.

1900. *Reynolds, Miss K. M. 8 Darnley-road, Notting Hill, W.

1870. *REYNOLDS, OSBORNE, M.A., LL.D., F.R.S., M.Inst.C.E. (Pres. G, 1887.) St. Decuman's, Watchet, Somerset.

1906. ‡Reynolds, S. H., M.A., Professor of Geology and Zoology in the University of Bristol.

1907. §Reynolds, W. Birstall Holt, near Leicester.

1899. *RHYS, The Right Hon. Professor Sir JOHN, D.Sc. (Pres. H, 1900.) Jesus College, Oxford.

1877. *Riccardi, Dr. Paul, Secretary of the Society of Naturalists. Riva Muro 14, Modena, Italy.

1905. §Rich, Miss Florence, M.A. Granville School, Granville-road, Leicester.

1906. ‡Richards, Rev. A. W. 12 Bootham-terrace, York.

1869. *Richardson, Charles. 3 Cholmley-villas, Long Ditton, Surrey.

1889. ‡Richardson, Hugh, M.A. 12 St. Mary's, York.

1884. *Richardson, J. Clarke Derwen Fawr, Swansea.

1896. *Richardson, Nelson Moore, B.A., F.E.S. Montevideo, Chickerell, near Weymouth.

1901. *Richardson, Professor Owen Willans. 105 Fitzrandolph-road, Princetown, N.J., U.S.A.

1876. §Richardson, William Haden. City Glass Works, Glasgow

1883. *RIDEAL, SAMUEL, D Sc., F.C.S. 28 Victoria-street, S.W

1911. §Ridgeway, Miss A. R. 83 The Broadway, Watford.

1902. §RIDGEWAY, WILLIAM, M.A., D.Litt., F.B.A. (Pres. H, 1908), Professor of Archæology in the University of Cambridge. Flendyshe, Fen Ditton, Cambridge.

1894. ‡RIDLEY, E. P., F.G.S. (Local Sec. 1895.) Burwood, Westerfield-road, Ipswich.

1881. *Rigg, Arthur. 150 Blomfield-terrace, W.

1883. *RIGG, EDWARD, C.B., I.S.O., M.A. Royal Mint, E.

1910. ‡Ripper, William, Professor of Engineering in the University of Sheffield.

1892. ‡Rintoul, D., M.A. Clifton College, Bristol.

1905. ‡Ritchie, Professor W., M.A. South African College, Cape Town.

1903. *RIVERS, W. H. R., M.D., F.R.S. (Pres. H, 1911.) St. John's College, Cambridge.

1908. *Roaf, Herbert E., M.D., D.Sc. 44 Rotherwick-road, Hendon, N.W.

1898. *Robb, Alfred A. Lisnabreeny House, Belfast.

1902. *Roberts, Bruno. 30 St. George's-square, Regent's Park, N.W.

1887. *Roberts, Evan. 30 St. George's-square, Regent's Park, N.W.

1896. ‡Roberts, Thomas J. Ingleside, Park-road, Huyton, near Liverpool.

Year of Election.

1897. §ROBERTSON, Sir GEORGE S., K.C.S.I. (Pres. E, 1900.) 1 Pump-court, Temple, E.C.

1905. ‡Robertson, Dr. G. W. Office of the Medical Officer of Health, Cape Town.

1897. ‡Robertson, Professor J. W., C.M.G., LL.D. The Macdonald College, St. Anne de Bellevue, Quebec, Canada.

1901. *Robertson, Robert, B.Sc., M.Inst.C.E. 154 West George-street, Glasgow.

1905. ‡Robertson, Professor T. E. Transvaal Technical Institute, Johannesburg.

1898. ‡Robinson, Charles E., M.Inst.C.E. Holne Cross, Ashburton, South Devon.

1909. ‡Robinson, E. M. 381 Main-street, Winnipeg, Canada.

1910. §Robinson, Lady E. Maude. The Manor, Worksop.

1903. ‡Robinson, G. H. 1 Weld-road, Southport.

1905. ‡Robinson, Harry. Duncan's-chambers, Shortmarket-street, Cape Town.

1902. †Robinson, Herbert C. Holmfield, Aigburth, Liverpool.

1906. ‡*ROBINSON, H. H., M.A., F.I.C. 75 Finborough-road, S.W.*

1911. §Robinson, J. J. 'West Sussex Gazette' Office, Arundel.

1902. ‡Robinson, James, M.A., F.R.G.S. Dulwich College, Dulwich, S.E.

1888. ‡Robinson, John, M.Inst.C.E. 8 Vicarage-terrace, Kendal.

1908. *Robinson, John Gorges. Cragdale, Settle, Yorkshire.

1910. ‡Robinson, John Hargreaves. Cable Ship 'Norseman,' Western Telegraph Co., Caixa no Correu No. 117, Pernambuco, Brazil.

1895. *Robinson, Joseph Johnson. 8 Trafalgar-road, Birkdale, Southport.

1905. ‡Robinson, Dr. Leland. 6 Victoria-walk, Woodstock, Cape Town.

1899. *Robinson, Mark, M.Inst.C.E. Parliament-chambers, Westminster, S.W.

1875. *Robinson, Robert, M.Inst.C.E. Beechwood, Darlington.

1908. ‡Robinson, Robert. Field House, Chesterfield.

1904. ‡Robinson, Theodore R. 25 Campden Hill-gardens, W.

1909. ‡Robinson, Captain W. 264 Roslyn-road, Winnipeg, Canada.

1909. ‡Robinson, Mrs. W. 264 Roslyn-road, Winnipeg, Canada.

1904. ‡Robinson, W. H. Kendrick House, Victoria-road, Penarth.

1870. *Robson, E. R. Palace Chambers, 9 Bridge-street, Westminster, S.W.

1906. ‡Robson, J. Nalton. The Villa, Hull-road, York.

1872. *Robson, William. 12 Albert-terrace, Edinburgh.

1885. *Rodger, Edward. 1 Clairmont-gardens, Glasgow.

1885. *Rodriguez, Epifanio. New Adelphi Chambers, 6 Robert-street, Adelphi, W.C.

1905. ‡Roebuck, William Denison, F.L.S. 259 Hyde Park-road, Leeds.

1907. ‡Roechling, H. Alfred, M.Inst.C.E. 39 Victoria-street, S.W.

1908. §Rogers, A. G. L. Board of Agriculture and Fisheries, 8 Whitehall-place, S.W.

1905. §Rogers, A. W., M.A., F.G.S. South African Museum, Cape Town.

1898. ‡ROGERS, BERTRAM, M.D. (Local Sec. 1898.) 11 York-place, Clifton, Bristol.

1907. ‡Rogers, John D. 85 St. George's-square, S.W.

1890. *Rogers, L. J., M.A., Professor of Mathematics in the University of Leeds. 15 Regent Park-avenue, Leeds.

1906. ‡Rogers, Reginald A. P. Trinity College, Dublin.

1909. ‡Rogers, Hon. Robert. Roslyn-road, Winnipeg, Canada.

1884. *Rogers, Walter. Lamorva, Falmouth.

1876. ‡ROLLIT, Sir A. K., B.A., LL.D., D.C.L., F.R.A.S., Hon. Fellow K.C.L. 45 Belgrave-square, S.W.

1905. ‡Rooth, Edward. Pretoria.

Year of Election.

1855. *ROSCOE, The Right Hon. Sir HENRY ENFIELD, B.A., Ph.D., LL.D., D.C.L., F.R.S. (PRESIDENT, 1887; Pres. B, 1870, 1884; Council, 1874–81; Local Sec. 1861.) 10 Bramham-gardens, S.W.

1905. ‡Rose, Miss G. Mabel. Ashley Lodge, Oxford.

1883. *Rose, J. Holland, Litt.D. Ethandune, Parkside-gardens, Wimbledon, S.W.

1905. ‡Rose, John G. Government Analytical Laboratory, Cape Town.

1894. *ROSE, T. K., D.Sc., Chemist and Assayer to the Royal Mint. 6 Royal Mint, E.

1905. *Rosedale, Rev. H. G., D.D., F.S.A. 36 Richmond-mansions, Earl's Court, S.W.

1905. *Rosedale, Rev. W. E., D.D. St. Mary Bolton's Vicarage, South Kensington, S.W.

1905. ‡Rosen, Jacob. 1 Hopkins-street, Yeoville, Transvaal.

1905. ‡Rosen, Julius. Clifton Grange, Jarvie-street, Jeppestown, Transvaal.

1900. ‡Rosenhain, Walter B.A. Warrawee, Coombe-lane, Kingston Hill, Surrey.

1909. ‡Ross, D. A. 116 Wellington-crescent, Winnipeg, Canada.

1859. *Ross, Rev. James Coulman. Wadworth Hall, Doncaster.

1908. ‡Ross, Sir John, of Bladensburg, K.C.B. Rostrevor House, Rostrevor, Co. Down.

1902. ‡Ross, John Callender. 46 Holland-street, Campden-hill, W.

1901. ‡Ross, Colonel Sir RONALD, K.C.B., F.R.S., Professor of Tropical Medicine and Parasitology in the University of Liverpool. The University, Liverpool.

1891. *Roth, H. Ling. Briarfield, Shibden, Halifax, Yorkshire.

1911. *Rothschild, Hon. L. Walter, M.P., D.Sc., Ph.D., F.R.S. Tring Park, Tring.

1905. ‡Rothkugel, R. Care of Messrs. D. Isaacs & Co., Cape Town.

1901. *Rottenburg, Paul, LL.D. Care of Messrs. Leister, Bock, & Co., Glasgow.

1899. *Round, J. C., M.R.C.S. 19 Crescent-road, Sydenham Hill, S.E.

1909. ‡Rounthwaite, C. H. E. Engineer's Office, Grand Trunk Pacific Railway of Canada, Winnipeg.

1884. *Rouse, M. L. Hollybank, Hayne-road, Beckenham.

1905. §Rousselet, Charles F. Fir Island, Bittacy Hill, Mill Hill, N.W.

1901. ‡Rowallan, the Right Hon. Lord. Thornliebank House, Glasgow.

1903. *Rowe, Arthur W., M.B., F.G.S. Shottendane, Margate.

1890. ‡Rowley, Walter, M.Inst.C.E., F.S.A. Alderhill, Meanwood, Leeds.

1881. *Rowntree, Joseph. 38 St. Mary's, York.

1910. §Rowse, Arthur A., B.A., B.Sc. Engineering Laboratory, Cambridge.

1875. *RÜCKER, Sir ARTHUR W., M.A., D.Sc., F.R.S. (PRESIDENT, 1901; TRUSTEE, 1898– ; GENERAL TREASURER, 1891–98; Pres. A, 1894; Council, 1888–91.) Everington House, Newbury, Berkshire.

1869. §RUDLER, F. W., I.S.O., F.G.S. Ethel Villa, Tatsfield, Westerham.

1901. *Rudorf, C. C. G., Ph.D., B.Sc. Ivor, Cranley-gardens, Muswell Hill, N.

1905. *Ruffer, Marc Armand, C.M.G., M.A., M.D., B.Sc. Quarantine International Board, Alexandria.

1905. ‡Ruffer, Mrs. Alexandria.

1904. ‡Ruhemann, Dr. S. 3 Selwyn-gardens, Cambridge.

1909. ‡Rumball, Rev. M. C., B.A. Morden, Manitoba, Canada.

1896. *Rundell, T. W., F.R.Met.Soc. 3 Fenwick-street, Liverpool.

1911. §Rundle, Henry, F.R.C.S. 13 Clarence-parade, Southsea.

1904. ‡Russell, E. J., D.Sc. Rothamsted Experimental Station, Harpenden, Herts.

Year of Election

1875. *Russell, The Hon. F. A. R. Steep, Petersfield.
Russell, John. 39 Mountjoy-square, Dublin.
1883. *Russell, J. W. 28 Staverton-road, Oxford.
1852. *Russell, Norman Scott. Arts Club, Dover-street, W.
1908. ‡Russell, Robert. Arduagremia, Haddon-road, Dublin.
1908. ‡RUSSELL, Right Hon. T. W., M.P. Olney, Terenure, Co. Dublin.
1886. ‡Rust, Arthur. Eversleigh, Leicester.
1909. *Rutherford, Alexander Cameron. Strathcona, Alberta, Canada.
1907. §RUTHERFORD, ERNEST, M.A., D.Sc., F.R.S. (Pres. A, 1909), Professor of Physics in the University of Manchester.
1909. ‡Ruttan, Colonel H. N. Armstrong's Point, Winnipeg, Canada.
1908. ‡Ryan, Hugh, D.Sc. Omdurman, Orwell Park, Rathgar, Dublin.
1905. ‡Ryan, Pierce. Rosebank House, Rosebank, Cape Town.
1909. ‡Ryan, Thomas. Assiniboine-avenue, Winnipeg, Canada.
1906. *RYMER, Sir JOSEPH SYKES. The Mount, York.

1903. ‡SADLER, M. E., C.B., LL.D. (Pres. L, 1906). Professor of Education in the Victoria University, Manchester. Eastwood, Weybridge.
1883. ‡Sadler, Robert. 7 Lulworth-road, Birkdale, Southport.
1871. ‡Sadler, Samuel Champernowne. Church House, Westminster, S.W.
1903. ‡Sagar, J. The Poplars, Savile Park, Halifax.
1873. *Salomons, Sir David, Bart., F.G.S. Broomhill, Tunbridge Wells.
1904. §SALTER, A. E., D.Sc., F.G.S. 5 Clifton-place, Brighton.
1911. §Sampson, R. A., M.A., F.R.S., Astronomer Royal for Scotland. Royal Observatory, Edinburgh.
1901. ‡Samuel, John S., J.P., F.R.S.E. City Chambers, Glasgow.
1907. *Sand, Dr. Henry J. S. University College, Nottingham.
1907. ‡Sandars, Miss Cora B. Parkholme, Elm Park-gardens, S.W.
Sandes, Thomas, A.B. Sallow Glin, Tarbert, Co. Kerry.
1896. §Saner, John Arthur, M.Inst.C.E. Highfield, Northwich.
1896. ‡Saner, Mrs. Highfield Northwich.
1903. ‡Sankey, Captain H. R., R.E., M.Inst.C.E. Palace-chambers, 9 Bridge-street, S.W.
1886. ‡Sankey, Percy E. 44 Russell-square, W.C.
1905. ‡Sargant, E. B. Quarry Hill, Reigate.
1896. *Sargant, Miss Ethel. Quarry Hill, Reigate.
1905. ‡Sargent, Miss Helen A., B.A. Huguenot College, Wellington, Cape Colony.
1907. §Sargent, H. C. Ambergate, near Derby.
1886. ‡Saundby, Robert, M.D. 83A Edmund-street, Birmingham.
1900. *SAUNDER, S. A. Fir Holt, Crowthorne, Berks.
1903. *Saunders, Miss E. R. Newnham College, Cambridge.
1901. ‡*Sawers, W. D. 1 Athole Gardens-place, Glasgow.*
1887. §SAYCE, Rev. A. H., M.A., D.D. (Pres. H, 1887), Professor of Assyriology in the University of Oxford. Queen's College, Oxford.
1906. ‡Sayer, Dr. Ettie. 35 Upper Brook-street, W.
1883. *Scarborough, George. Whinney Field, Halifax, Yorkshire.
1903. §SCARISBRICK, Sir CHARLES, J.P. Scarisbrick Lodge, Southport.
1903. ‡Scarisbrick, Lady. Scarisbrick Lodge, Southport.
1879. *SCHAFER, E. A, LL.D., D.Sc., M.D., F.R.S. (PRESIDENT ELECT; GENERAL SECRETARY, 1895–1900; Pres. I, 1894; Council, 1887–93), Professor of Physiology in the University of Edinburgh.

Year of Election.

1888. *SCHARFF, ROBERT F., Ph.D., B.Sc., Keeper of the Natural History Department, National Museum, Dublin.

1880. *Schemmann, Louis Carl. Neueberg 12, Hamburg.

1905. ‡Schonland, S., Ph.D. Albany Museum, Grahamstown, Cape Colony.

1908. ‡Schrödter, Dr. E. 27 Breite-strasse, Düsseldorf, Germany.

1873. *SCHUSTER, ARTHUR, Ph.D., F.R.S., F.R.A.S. (Pres. A, 1892; Council, 1887-93.) Kent House, Victoria Park, Manchester.

1905. ‡Sclander, J. E. P.O. Box 465, Cape Town.

1847. *SCLATER, PHILIP LUTLEY, M.A., Ph.D., F.R.S., F.L.S., F.G.S., F.R.G.S., F.Z.S. (GENERAL SECRETARY, 1876-81; Pres. D, 1875; Council, 1864-67, 1872-75.) Odiham Priory, Winchfield.

1883. *SCLATER, W. LUTLEY, M.A., F.Z.S. Odiham Priory, Winchfield.

1905. ‡Sclater, Mrs. W. L. Odiham Priory, Winchfield.

1881. *SCOTT, ALEXANDER, M.A., D.Sc., F.R.S., F.C.S. 34 Upper Hamilton-terrace, N.W.

1878. *Scott, Arthur William, M.A., Professor of Mathematics and Natural Science in St. David's College, Lampeter.

1889. *SCOTT, D. H., M.A., Ph.D., F.R.S., Pres.L.S. (GENERAL SECRETARY, 1900-03; Pres. K, 1896.) East Oakley House, Oakley, Hants; and Athenæum Club, Pall Mall, S.W.

1857. *SCOTT, ROBERT H., M.A., D.Sc., F.R.S., F.R.Met.S. 6 Elm Park-gardens, S.W.

1902. ‡Scott, William R., M.A., Litt.D. The University, St. Andrews, Scotland.

1895. ‡Scott-Elliot, Professor G. F., M.A., B.Sc., F.L.S. Newton, Dumfries.

1883. ‡Scrivener, Mrs. Haglis House, Wendover.

1909. ‡Scudamore, Colonel F. W. Chelsworth Hall, Suffolk.

1895. ‡Scull, Miss E. M. L. St. Edmund's, 10 Worsley-road, Hampstead, N.W.

1890. *Searle, G. F. C., M.A., F.R.S. Wyncote, Hills-road, Cambridge.

1880. ‡SEDGWICK, ADAM, M.A., F.R.S. (Pres. D, 1899), Professor of Zoology in the Imperial College of Science and Technology, London. 2 Sumner-place, S.W.

1905. ‡Sedgwick, C. F. Strand-street, Cape Town.

1906. *See, T. J. J., A.M., Ph.D., F.R.A.S., Professor of Mathematics, U.S. Navy. Naval Observatory, Mare Island, California.

1907. §Seligmann, Dr. C. G. 15 York-terrace, Regent's Park, N.W.

1911. *Seligmann, Mrs. C. G. 36 Finchley-road, N.W.

1904. †Sell, W. J. 19 Lensfield-road, Cambridge.

1909. ‡Sellars, H. Lee. 225 Fifth-avenue, New York, U.S.A.

1888. *SENIER, ALFRED, M.D., Ph.D., F.C.S., Professor of Chemistry in University College, Galway.

1888. *SENNETT, ALFRED R., A.M.Inst.C.E. Duffield, near Derby.

1870. *Sephton, Rev. J. 90 Huskisson-street, Liverpool.

1905. ‡Serrurier, Louis C. Ashley, Sea Point, Cape Town.

1910. ‡Seton, R. S., B.Sc. The University, Leeds.

1895. *Seton-Karr, H. W. 8 St. Paul's-mansions, Hammersmith, W.

1892. *SEWARD, A. C., M.A., F.R.S., F.G.S. (Pres. K, 1903; Council, 1901-07; Local Sec. 1904), Professor of Botany in the University of Cambridge. Westfield, Huntingdon-road, Cambridge.

1899. §Seymour, Professor Henry J., B.A., F.G.S. University College, Earlsfort-terrace, Dublin.

1891. ‡Shackell, E. W. 191 Newport-road, Cardiff.

1905. *Shackleford, W. C., M.Inst.M.E. County Club, Lancaster.

Year of Election.

1904. ‡Shackleton, Lieutenant Sir Ernest H., M.V.O., F.R.G.S. 14 South Learmonth-gardens, Edinburgh.
1902. ‡SHAFTESBURY, The Right Hon. the Earl of, K.P., K.C.V.O. Belfast Castle, Belfast.
1901. *Shakespear, Mrs. G. A. 21 Woodland-road, Northfield, Worcestershire.
1906. ‡Shann, Frederick. 6 St. Leonard's, York.
1878. ‡SHARP, DAVID, M.A., M.B., F.R.S., F.L.S. Museum of Zoology, Cambridge.
1904. ‡Sharples, George. 181 Great Cheetham-street West, Higher Broughton, Manchester.
1910. §Shaw, J. J. Sunnyside, Birmingham-road, West Bromwich.
1889. *Shaw, Mrs. M. S., B.Sc. Brookhayes, Exmouth.
1883. *SHAW, W. N., M.A., Sc.D., F.R.S. (Pres. A, 1908; Council, 1895–1900, 1904–07.) Meteorological Office, South Kensington, S.W.
1883. ‡Shaw, Mrs. W. N. 10 Moreton-gardens, South Kensington, S.W.
1904. ‡Shaw-Phillips, Miss. 70 Westbourne-terrace, Hyde Park, W.
1903. ‡Shaw-Phillips, T., J.P. The Times Library Club, 380 Oxford-street, W.
1905. ‡Shenstone, Miss A. Sutton Hall, Barcombe, Lewes.
1905. ‡Shenstone, Mrs. A. E. G. Sutton Hall, Barcombe, Lewes.
1865. ‡Shenstone, Frederick S. Sutton Hall, Barcombe, Lewes.
1900. §Sheppard, Thomas, F.G.S. The Municipal Museum, Hull.
1908. §Sheppard, W. F., Sc.D., LL.M. Board of Education, Whitehall, S.W.
1905. ‡Sheridan, Dr. Norman. 96 Francis-street, Bellevue, Johannesburg.
1883. ‡Sherlock, David. Rahan Lodge, Tullamore, Dublin.
1883. ‡Sherlock, Mrs. David. Rahan Lodge. Tullamore, Dublin.
1896. ‡SHERRINGTON, C. S., M.D., D.Sc., F.R.S. (Pres. I, 1904; Council, 1907–), Professor of Physiology in the University of Liverpool. 16 Grove-park, Liverpool.
1888. *Shickle, Rev. C. W., M.A., F.S.A. St. John's Hospital, Bath.
1908. *Shickle, Miss Mabel G. M. 9 Cavendish-crescent, Bath.
1902. *Shillington, T. Foulkes, J.P. Dromart, Antrim-road, Belfast.
1883. *Shillitoe, Buxton, F.R.C.S. 29 Sydenham-hill, S.E.
1887. *SHIPLEY, ARTHUR E., M.A., D.Sc., F.R.S. (Pres. D, 1909; Council, 1904–11), Master of Christ's College, Cambridge.
1909. ‡Shipley, J. W., B.A. University of Manitoba, Winnipeg, Canada.
1897. ‡SHORE, Dr. LEWIS E. St. John's College, Cambridge.
1882. ‡SHORE, T. W., M.D., B.Sc., Lecturer on Comparative Anatomy at St. Bartholomew's Hospital. 6 Kingswood-road, Upper Norwood, S.E.
1901. ‡Short, Peter M., B.Sc. 1 Deronda-road, Herne Hill, S.E.
1908. §Shorter, Lewis R., B.Sc. 55 Campden Hill-road, W.
1904. *Shrubsall, F. C., M.A., M.D. 34 Lime-grove, Uxbridge-road, W.
1910. ‡Shuttleworth, T. E. 5 Park-avenue, Riverdale-road, Sheffield.
1889. ‡Sibley, Walter K., M.A., M.D. The Mansions, 70 Duke-street, W.
1902. ‡Siddons, A. W., M.A. Harrow-on-the-Hill, Middlesex.
1883. *Sidebotham, Edward John. Erlesdene, Bowdon, Cheshire.
1877. *Sidebotham, Joseph Watson. Merlewood, Bowdon, Cheshire.
1873. *SIEMENS, ALEXANDER, M.Inst.C.E. Caxton House, Westminster, S.W.
1905. ‡Siemens, Mrs. A. Caxton House, Westminster, S.W.
1903. *Silberrad, Dr. Oswald. Buckhurst Hill, Essex.
1871. *SIMPSON, Sir ALEXANDER R., M.D., Emeritus Professor of Midwifery in the University of Edinburgh. 52 Queen-street, Edinburgh.

Year of Election.

1863. ‡Simpson, J. B., F.G.S. Hedgefield House, Blaydon-on-Tyne.
1909. ‡Simpson, Professor J. C. McGill University, Montreal, Canada.
1908. ‡Simpson, J. J., M.A., B.Sc. Zoological Department, Marischal College, Aberdeen.
1901. *Simpson, Professor J. Y., M.A., D.Sc., F.R.S.E. 25 Chester-street, Edinburgh.
1907. ‡Simpson, Lieut.-Colonel R. J. S., C.M.G. 66 Shooters Hill-road, Blackheath, S.E.
1909. *Simpson, Samuel, B.Sc. Ribblesdale, Elmcroft-crescent, Golder's Green, N.W.
1909 ‡Simpson, Sutherland, M.D. Cornell University Medical College. Ithaca, New York, U.S.A.
1896. *SIMPSON, W., F.G.S. Catteral Hall, Settle, Yorkshire.
1884. *Simpson, Professor W. J. R., C.M.G., M.D. 31 York-terrace, Regent's Park, N.W.
1909. ‡Sinclair, J. D. 77 Spence-street, Winnipeg.
1874. ‡SINCLAIR, Right Hon. THOMAS. (Local Sec. 1874.) Dunedin, Belfast.
1907. *Sircar, Dr. Amrita Lal, L.M.S., F.C.S. 51 Sankaritola, Calcutta.
1905. *SJÖGREN, Professor H. Natural History Museum, Stockholm, Sweden.
1902. ‡Skeffington, J. B., M.A., LL.D. Waterford.
1906. ‡Skerry, H. A. St. Paul's-square, York.
1883. ‡Skillicorne, W. N. 9 Queen's-parade, Cheltenham.
1910. §Skinner, J. C. 76 Ivy Park-road, Sheffield.
1898. ‡SKINNER, SIDNEY, M.A. (Local Sec. 1904.) South-Western Polytechnic, Manresa-road, Chelsea, S.W.
1905. *Skyrme, C. G. 28 Norman-road, St. Leonards-on-Sea.
1905. ‡Slator, Dr. H. B. 75 Bree-street, Johannesburg.
1889. §Slater, Matthew B., F.L.S. Malton, Yorkshire.
1887. ‡Small, Evan W., M.A., B.Sc., F.G.S. 48 Kedleston-road, Derby.
1903. *Smallman, Raleigh S. Homeside, Devonshire-place, Eastbourne.
1904. ‡Smart, Edward. Benview, Craigie, Perth, N.B.
1889. *SMART, Professor WILLIAM, LL.D. (Pres. F, 1904.) Nunholme, Dowanhill, Glasgow.
1902. §Smedley, Miss Ida. 36 Russell-square, W.C.
1911. §Smiles, Samuel. The Quarry, Sanderstead-road, Sanderstead, Surrey.
1911. §Smith, A. Malins. St. Audrey's Mill House, Thetford, Norfolk.
1905. ‡Smith, Miss Adelaide. Huguenot College, Wellington, Cape Colony.
1892. ‡Smith, Alexander, B.Sc., Ph.D., F.R.S.E. Department of Chemistry, Columbia University, New York, U.S.A.
1908 ‡Smith, Alfred. 30 Merrion-square, Dublin.
1897. ‡Smith, Andrew, Principal of the Veterinary College, Toronto, Canada.
1901. *Smith, Miss Annie Lorrain. 20 Talgarth-road, West Kensington, W.
1874. *Smith, Benjamin Leigh, F.R.G.S. Oxford and Cambridge Club, Pall Mall, S.W.
1873. ‡Smith, C. Sidney-Sussex College, Cambridge.
1905. ‡Smith, C. H. Fletcher's-chambers, Cape Town.
1910. ‡Smith, Charles. 11 Winter-street, Sheffield.
1889. *Smith, Professor C. Michie, C.I.E., B.Sc., F.R.S.E., F.R.A.S. The Observatory, Kodaikanal, South India.
1900. §Smith, E. J. Grange House, Westgate Hill, Bradford.

Year of Election

1908. ‡Smith, E. Shrapnell. 7 Rosebery-avenue, E.C.
1886. *Smith, Mrs. Emma. Hencotes House, Hexham.
1901. §Smith, F. B. Care of A. Croxton Smith, Esq., Burlington House, Wandle-road, Upper Tooting, S.W.
1866. *Smith, F. C. Bank, Nottingham.
1911. §Smith, F. E. Redcot, St. James's-avenue, Hampton Hill.
1897. ‡SMITH, G. ELLIOT, M.D., F.R.S., Professor of Anatomy in the University of Manchester.
1911. §Smith, Geoffrey W., M.A., F.L.S. New College, Oxford.
1903. *SMITH, Professor H. B. LEES, M.A., M.P. The University, Bristol.
1910. §Smith, H. Bompas, M.A. King Edward VII. School, Lytham.
1889. *SMITH, Sir H. LLEWELLYN, K.C.B., M.A., B.Sc., F.S.S. (Pres. F, 1910.) Board of Trade, S.W.
1860. *Smith, Heywood, M.A., M.D. 40 Portland-court, W.
1876. *Smith, J. Guthrie. 5 Kirklee-gardens, Kelvinside, Glasgow.
1902. ‡Smith, J. Lorrain, M.D., F.R.S., Professor of Pathology in the Victoria University, Manchester.
1903. *Smith, James. Pinewood, Crathes, Aberdeen.
1911. §Smith, Priestley, F.R.C.S., Professor of Ophthalmology in the University of Birmingham. 95 Cornwall-street, Birmingham.
1910. ‡Smith, Samuel. Central Library, Sheffield.
1894. §Smith, T. Walrond. Care of Frank Henderson, Esq., 10 Manor-road, Sidcup, Kent.
1910. ‡Smith, W. G., B.Sc., Ph.D. College of Agriculture, Edinburgh.
1896. *Smith, Rev. W. Hodson. Newquay, Cornwall.
1911. §Smith, W. Parnell. The Grammar School, Portsmouth.
1885. *Smith, Watson. 34 Upper Park-road, Haverstock Hill, N.W.
1909. ‡Smith, William. 218 Sherbrooke-street, Winnipeg, Canada.
1883. ‡SMITHELLS, ARTHUR, B.Sc., F.R.S. (Pres. B, 1907; Local Sec. 1890), Professor of Chemistry in the University of Leeds.
1906. §Smurthwaite, Thomas E., F.R.A.I. 134 Mortimer-road, Kensal Rise, N.W.
1905. §Smuts, C. P.O. Box 1088, Johannesburg.
1909. §Smylie, Hugh. 13 Donegall-square North, Belfast.
1857. *SMYTH, JOHN, M.A., F.C.S., F.R.M.S., M.Inst.C.E.I. Milltown, Banbridge, Ireland.
1908. §Smythe, J. A., Ph.D., D.Sc. 10 Queen's-gardens, Benton, Newcastle-on-Tyne.
1888. *SNAPE, H. LLOYD, D.Sc., Ph.D. Balholm, Lathom-road, Southport.
1905. ‡SODDY, F., M.A., F.R.S. The University, Glasgow.
1905. ‡Sollas, Miss I. B. J., B.Sc. Newnham College, Cambridge.
1879. *SOLLAS, W. J., M.A., Sc.D., F.R.S., F.R.S.E., F.G.S. (Pres. C, 1900; Council, 1900–03), Professor of Geology in the University of Oxford. 173 Woodstock-road, Oxford.
1905. ‡Solomon, R. Stuart. Care of Messrs. R. M. Moss & Co., Cape Town.
1900. *SOMERVILLE, W., D.Sc., F.L.S., Sibthorpian Professor of Rural Economy in the University of Oxford. 121 Banbury-road, Oxford.
1910. *Sommerville, Duncan M. Y. 70 Argyle-street, St. Andrews, N.B.
1901. ‡Sorley, Robert. The Firs, Partickhill, Glasgow.
1903. ‡Soulby, R. M. Sea Holm, Westbourne-road, Birkdale, Lancashire.
1903. ‡Southall, Henry T. The Graig, Ross, Herefordshire.
1865. *Southall, John Tertius. Parkfields, Ross, Herefordshire.
1883. ‡Spanton, William Dunnett, F.R.C.S. Chatterley House, Hanley, Staffordshire.

Year of Election.

1909. ‡Sparling, Rev. J. W., D.D. 159 Kennedy-street, Winnipeg, Canada.

1893. *Speak, John. Kirton Grange, Kirton, near Boston.

1910. ‡Spearman, C. Birnam, Guernsey.

1905. ‡Spencer, Charles Hugh. P.O. Box 2, Maraisburg, Transvaal.

1910. §Spicer, Rev. E. C. The Rectory, Waterstock, Oxford.

1864. *Spicer, Henry, B.A., F.L.S., F.G.S. 14 Aberdeen-park, Highbury, N.

1894. ‡Spiers, A. H. Gresham's School, Holt, Norfolk.

1864. *SPILLER, JOHN, F.C.S. 2 St. Mary's-road, Canonbury, N.

1864. *Spottiswoode, W. Hugh, F.C.S. 6 Middle New-street, Fetter-lane, E.C.

1909. ‡Sprague, D. E. 76 Edmonton-street, Winnipeg, Canada.

1854. *SPRAGUE, THOMAS BOND, M.A., LL.D., F.R.S.E. 29 Buckingham-terrace, Edinburgh.

1888. *Stacy, J. Sargeant. 164 Shoreditch, E.

1903. ‡Stallworthy, Rev. George B. The Manse, Hindhead, Haslemere, Surrey.

1883. *Stanford, Edward, F.R.G.S. 12-14 Long-acre, W.C.

1905. ‡Stanley, Professor George H. Transvaal Technical Institute, Johannesburg.

1883. ‡Stanley, Mrs Cumberlow, South Norwood, S E.

1894. *STANSFIELD, ALFRED, D.Sc. McGill University, Montreal, Canada.

1909. §Stansfield, Edgar. Mines Branch, Department of Mines, Ottawa, Canada.

1911. §Stapf, Dr. Otto, F.R.S. Royal Gardens, Kew.

1900. *STANSFIELD, H., D.Sc., A.I.E.E. The University, Manchester.

1905. ‡Stanwell, Dr. St. John. P.O. Box 1050, Johannesburg.

1905. ‡Stapleton, Frederick. Control and Audit Office, Cape Town.

1905. **Starkey, A. H.* 24 *Greenhead-road, Huddersfield.*

1899. ‡STARLING, E. H., M.D., F.R.S. (Pres. I, 1909), Professor of Physiology in University College, London, W.C.

1898. ‡Stather, J. W., F.G.S. Brookside, Newland Park, Hull.

Staveley, T. K. Ripon, Yorkshire.

1907. §Staynes, Frank. 36-38 Silver-street, Leicester.

1910. ‡Stead, F. B. 80 St. Mary's-mansions, Paddington, W.

1900. *STEAD, J. E., F.R.S. (Pres. B, 1910.) Laboratory and Assay Office, Middlesbrough.

1881. ‡Stead, W. H. Beech-road, Reigate.

1892. *STEBBING, Rev. THOMAS R. R., M.A., F.R.S. Ephraim Lodge, The Common, Tunbridge Wells.

1896. *STEBBING, W. P. D., F.G.S. 78A Lexham-gardens, W.

1905. ‡Stebbins, Miss Inez F., B.A. Huguenot College, Wellington, Cape Town

1911. §Steele, L. J., M.I.E.E. H.M. Dockyard, Portsmouth.

1908. ‡Steele, Lawrence Edward, M.A., M.R.I.A. 18 Crosthwaite-park East, Kingstown, Co. Dublin.

1911. §Stein, M. Aurel, C.I.E., D.Sc., D.Litt. Merton College, Oxford.

1909. ‡Steinkopj, Max. 667 Main-street, Winnipeg, Canada.

1905. ‡Stephen, J. M. Invernegie, Sea Point, Cape Colony.

1884. *Stephens, W. Hudson. Low-Ville, Lewis County, New York, U.S.A.

1902. ‡Stephenson, G. Grianan, Glasnevin, Dublin.

1910. *STEPHENSON, H. K. Banner Cross Hall, Sheffield.

1909. ‡Stethem, G. A. Fort Frances, Ontario, Canada.

1908. *Steven, Alfred Ingram, M.A., B.Sc. 50 Onslow-road, Fairfield, Liverpool.

1906. ‡Stevens, Miss C. O. The Plain, Foxcombe Hill, Oxford.

Year of Election.

1880. *Stevens, J. Edward, LL.B. Le Mayals, Blackpill, R.S.O.

1900. ‡STEVENS, FREDERICK. (Local Sec. 1900.) Town Clerk's Office, Bradford.

1905. ‡Stewart, A. F. 127 Isabella-street, Toronto, Canada.

1905. ‡Stewart, Charles. Meteorological Commission, Cape Town.

1909. ‡Stewart, David A., M.D. 407 Pritchard-avenue, Winnipeg, Canada.

1875. *Stewart, James, B.A., F.R.C.P.Ed. Junior Constitutional Club, Piccadilly, W.

1901. *Stewart, John Joseph, M.A., B.Sc. 2 Stow Park-crescent, Newport, Monmouthshire.

1901. *Stewart, Thomas. St. George's-chambers, Cape Town.

1911. §Stibbs, H. A. Portsea Island Gas Company, Commercial-road, Portsmouth.

1876. ‡STIRLING, WILLIAM, M.D., D.Sc., F.R.S.E., Professor of Physiology in the Victoria University, Manchester.

1904. ‡Stobbs, J. T. Dunelm, Basford Park, Stoke-on-Trent.

1906. *Stobo, Mrs. Annie. Somerset House, Garelochhead, Dumbartonshire, N.B.

1901. *Stobo, Thomas. Somerset House, Garelochhead, Dumbartonshire, N.B.

1883. *STOCKER, W. N., M.A. Brasenose College, Oxford.

1898. *Stokes, Professor George J., M.A. 5 Fernhurst-villas, College-road, Cork.

1899. *Stone, Rev. F. J. Radley College, Abingdon.

1874. ‡Stone, J. Harris, M.A., F.L.S., F.C.S. 3 Dr. Johnson's-buildings, Temple, E.C.

1905. ‡Stoneman, Miss Bertha, D.Sc. Huguenot College, Wellington, Cape Colony.

1895. *Stoney, Miss Edith A. 30 Chepstow-crescent, W.

1908. *Stoney, Miss Florence A., M.D. 4 Nottingham-place, W.

1878. *Stoney, G. Gerald, F.R.S. Oakley, Heaton-road, Newcastle-upon-Tyne.

1883. ‡Stopes, Mrs. 7 Denning-road, Hampstead, N.W.

1903. *Stopes, Dr. Marie C. 14 Well-walk, Hampstead, N.W.

1910. §Storey, Gilbert. Lime Grove, Brooklands, near Manchester.

1887. *Storey, H. L. Bailrigg, Lancaster.

1888. *Stothert, Percy K. Woolley Grange, Bradford-on-Avon, Wilts.

1905. *Stott, Clement H., F.G.S. P.O. Box 7, Pietermaritzburg, Natal.

1881. ‡STRAHAN, AUBREY, M.A., F.R.S., F.G.S. (Pres. C, 1904.) Geological Museum, Jermyn-street, S.W.

1905. ‡Strange, Harold F. P.O. Box 2527, Johannesburg.

1908. *Stratton, F. J. M., M.A. Gonville and Caius College, Cambridge.

1906. *Stromeyer, C. E. 9 Mount-street, Albert-square, Manchester.

1883. §Strong, Henry J., M.D. Colonnade House, The Steyne, Worthing.

1898. *Strong, W. M., M.D. 3 Champion-park, Denmark Hill, S.E.

1887. *Stroud, H., M.A., D.Sc., Professor of Physics in the Armstrong College, Newcastle-upon-Tyne.

1887. *STROUD, WILLIAM, D.Sc., Professor of Physics in the University of Leeds. Care of Messrs. Barr & Stroud, Anniesland, Glasgow.

1905. ‡Struben, Mrs. A. P.O. Box 1228, Pretoria.

1876. *Stuart, Charles Maddock, M.A. St. Dunstan's College, Catford, S.E.

1872. *Stuart, Rev. Canon Edward A., M.A. The Precincts, Canterbury.

1885. ‡Stump, Edward C. Malmesbury, Polefield, Blackley, Manchester.

1909. ‡Stupart, R. F. Meteorological Service, Toronto, Canada.

1879. *Styring, Robert. Brinkcliffe Tower, Sheffield.

Year of Election.

1891. *Sudborough, Professor J. J., Ph.D., D.Sc. University College of Wales, Aberystwyth.
1902. §Sully, H. T. Scottish Widows-buildings, Bristol.
1898. §Sully, T. N. Avalon House, Queen's-road, Weston-super-Mare.
1905. ‡Summer, A. B. Ollersett Booyseux, Transvaal.
1911. §Summers, A. H., M.A. 16 St. Andrew's-road, Southsea.
1887. *Sumpner, W. E., D.Sc. Technical School, Suffolk-street, Birmingham.
1911. §Sutton, Leonard, F.L.S. Hillside, Reading.
1911. §Sutton, W. L., F.I.C. Hillcroft, Eaton, Norwich.
1908. §Sutherland, Alexander. School House, Gersa, Watten, Caithness.
1903. ‡Swallow, Rev. R. D., M.A. Chigwell School, Essex.
1905. ‡Swan, Miss Hilda. Overhill, Warlingham, Surrey.
1881. §SWAN, Sir JOSEPH WILSON, M.A., D.Sc., F.R.S. Overhill, Warlingham, Surrey.
1905. ‡Swan, Miss Mary E. Overhill, Warlingham, Surrey.
1911. *Swann, Dr. W. F. G. 435 Glossop-road, Sheffield.
1897. ‡Swanston, William, F.G.S. Mount Collyer Factory, Belfast.
1908. ‡Swanzy, Sir Henry R., M.D. 23 Merrion-square, Dublin.
1887. §SWINBURNE, JAMES, F.R.S., M.Inst.C.E. 82 Victoria-street, S.W.
1870. *Swinburne, Sir John, Bart. Capheaton Hall, Newcastle-upon-Tyne.
1902. *Sykes, Miss Ella C. Elcombs, Lyndhurst, Hampshire.
1887. *Sykes, George H., M.A., M.Inst.C.E., F.S.A. Glencoe, 64 Elmbourne-road, Tooting Common, S.W.
1896. *Sykes, Mark L., F.R.M.S. 10 Headingley-avenue, Leeds.
1902. *Sykes, Major P. Molesworth, C.M.G. Elcombs, Lyndhurst, Hampshire.
1906. ‡Sykes, T. P., M.A. 4 Gathorne-street, Great Horton, Bradford.
1905. ‡Symington, C., M.B. Railway Medical Office, De Aar, Cape Colony.
1903. §Symington, Howard W. Brooklands, Market Harborough.
1885. ‡SYMINGTON, JOHNSON, M.D., F.R.S., F.R.S.E. (Pres. H, 1903), Professor of Anatomy in Queen's University, Belfast.
1905. ‡Symmes, H. C. P.O. Box 3902, Johannesburg.
1908. ‡Synnott, Nicholas J. Furness, Naas, Co. Kildare.

1910. *Tait, John, M.D., D.Sc. 2 Parkside-terrace, Edinburgh.
1904. §Tallack, H. T. Clovelly, Birdhurst-road, South Croydon.
1903. *Tanner, Miss Ellen G. Parkside, Corsham, Wilts.
1890. ‡TANNER, H. W. LLOYD, D.Sc., F.R.S. (Local Sec. 1891.) University College, Cardiff.
1892. *TANSLEY, ARTHUR G., M.A., F.L.S. Grantchester, near Cambridge.
1908. ‡TARLETON, FRANCIS A., LL.D. 24 Upper Leeson-street, Dublin.
1861. *Tarratt, Henry W. 2c Oxford and Cambridge-mansions, Hyde Park, W.
1902. ‡Tate, Miss. Rantalard, Whitehouse, Belfast.
1908. ‡Taylor, Rev. Campbell, M.A. United Free Church Manse, Wigtown, Scotland.
1887. ‡Taylor, G. H. Holly House, 235 Eccles New-road, Salford.
1898. ‡Taylor, Lieut.-Colonel G. L. Le M. 6 College-lawn, Cheltenham.
1881. *Taylor, H. A. 12 Melbury-road, Kensington, W.
1906. ‡Taylor, H. Dennis. Stancliffe, Mount-villas, York.
1884. *TAYLOR, H. M., M.A., F.R.S. Trinity College, Cambridge.
1882. *Taylor, Herbert Owen, M.D. Oxford-street, Nottingham.
1860. *Taylor, John, M.Inst.C.E. 6 Queen Street-place, E.C.

Year of
Election.

1906. §Taylor, Miss M. R. Nowstead, Blundellsands.
1884. *Taylor, Miss S. Oak House, Shaw, near Oldham.
1894. *Taylor, W. W., M.A. 66 St. John's-road, Oxford.
1901. *Teacher, John H., M.B. 32 Kingsborough-gardens, Glasgow.
1858. ‡TEALE, THOMAS PRIDGIN, M.A., F.R.S. 38 Cookridge-street, Leeds.
1885. ‡TEALL, J. J. H., M.A., D.Sc., F.R.S., F.G.S. (Pres. C, 1893; Council, 1894–1900, 1909–), Director of the Geological Survey of the United Kingdom. The Museum, Jermyn-street, S.W.
1906. *Teape, Rev. W. M., M.A. South Hylton Vicarage, Sunderland.
1910. ‡Tebb, W. Scott, M.A., M.D. 15 Finsbury-circus, E.C.
1879. ‡Temple, Lieutenant G. T., R.N., F.R.G.S. Solheim, Cumberland Park, Acton, W.
1896. *Terry, Rev. T. R., M.A., F.R.A.S. The Rectory, East Ilsley, Newbury, Berkshire.
1892. *Tesla, Nikola. 45 West 27th-street, New York, U.S.A.
1883. ‡Tetley, C. F. The Brewery, Leeds.
1883. ‡Tetley, Mrs. C. F. The Brewery, Leeds.
1882. *THANE, GEORGE DANCER, LL.D., Professor of Anatomy in University College, London, W.C.
1871. ‡THISELTON-DYER, Sir W. T., K.C.M.G., C.I.E., M.A., B.Sc., Ph.D., LL.D., F.R.S., F.L.S. (Pres. D, 1888; Pres. K, 1895; Council, 1885–89, 1895–1900.) The Ferns, Witcombe, Gloucester.
1906. *Thoday, D. The University, Manchester.
1906. *Thoday, Mrs. M. G. 25 Halifax-road, Cambridge.
1870. ‡Thom, Colonel Robert Wilson, J.P. Brooklands, Lord-street West, Southport.
1891. *Thomas, Miss Clara. Pencerrig, Builth.
1903. *THOMAS, Miss ETHEL N., B.Sc. 3 Downe-mansions, Gondar-gardens, West Hampstead, N.W.
1910. §Thomas, H. Hamshaw. Botany School, Cambridge.
1880. *Thomas, Joseph William, F.C.S. Overdale, Shortlands, Kent.
1899. *Thomas, Mrs. J. W. Overdale, Shortlands, Kent.
1902. *Thomas, Miss M. Beatrice. Girton College, Cambridge.
1883. ‡Thomas, Thomas H. 45 The Walk, Cardiff.
1904. *Thomas, William, F.R.G.S. Bryn-heulog, Merthyr Tydfil.
1891. *Thompson, Beeby, F.C.S., F.G.S. 67 Victoria-road, Northampton.
1888. *Thompson, Claude M., M.A., D.Sc., Professor of Chemistry in University College, Cardiff. 38 Park-place, Cardiff.
1885. ‡THOMPSON, D'ARCY W., C.B., B.A. (Pres. D. 1911; LOCAL SECRETARY. 1912), Professor of Zoology in University College, Dundee.
1896. *Thompson, Edward P. Paulsmoss, Whitchurch, Salop.
1907. *Thompson, Edwin. 25 Sefton-drive, Liverpool.
1883. *Thompson, Francis. Eversley, Haling Park-road, Croydon.
1904. *Thompson, G. R., B.Sc., F.G.S., Principal of and Professor of Mining in the South African School of Mines, Johannesburg.
1893. *Thompson, Harry J., M.Inst.C.E., Madras. Care of National Bank of India, 17 Bishopsgate-street Within, E.C.
1883. *Thompson, Henry G., M.D. 86 Lower Addiscombe-road, Croydon.
1905. ‡Thompson, James. P.O. Box 312, Johannesburg.
1876. *Thompson, Richard. Dringcote, The Mount, York.
1876. ‡THOMPSON, SILVANUS PHILLIPS, B.A., D.Sc., F.R.S., F.R.A.S. (Pres. G, 1907; Council, 1897–99, 1910–), Principal of and Professor of Physics in the City and Guilds of London Technical College, Leonard-street, Finsbury, E.C.

Year of Election.

1883. *Thompson, T. H. Oldfield Lodge, Gray-road, Bowdon, Cheshire.

1896. *THOMPSON, W. H., M.D., D.Sc. (Local Sec. 1908), King's Professor of Institutes of Medicine (Physiology) in Trinity College, Dublin. 14 Hatch-street, Dublin.

1911. §Thompson, Mrs. W. H. 328 Assiniboine-avenue, Winnipeg.

1905. ‡*Thompson, William. Parkside, Doncaster-road, Rotherham.*

1894. ‡THOMSON, ARTHUR, M.A., M.D., Professor of Human Anatomy in the University of Oxford. Exeter College, Oxford.

1909. *Thomson, E. 22 Monument-avenue, Swampscott, Mass., U.S.A.

1906. §Thomson, F. Ross, F.G.S. Hensill, Hawkhurst, Kent.

1890. *THOMSON, Professor J. ARTHUR, M.A., F.R.S.E. Castleton House, Old Aberdeen.

1883. ‡THOMSON, Sir J. J., M.A., Sc.D., D.Sc., F.R.S. (PRESIDENT, 1909; Pres. A, 1896; Council, 1893-95), Professor of Experimental Physics in the University of Cambridge. Trinity College, Cambridge.

1901. ‡Thomson, Dr. J. T. Kilpatrick. 148 Norfolk-street, Glasgow.

1889. *Thomson, James, M.A. 22 Wentworth-place, Newcastle-upon-Tyne.

1902. ‡Thomson, James Stuart. 29 Ladysmith-road, Edinburgh.

1891. ‡Thomson, John. Westover, Mount Ephraim-road, Streatham, S.W.

1871. *THOMSON, JOHN MILLAR, LL.D., F.R.S. (Council, 1895-1901), Professor of Chemistry in King's College, London. 18 Lansdowne-road, Holland Park, W.

1874. §THOMSON, WILLIAM, F.R.S.E., F.C.S. Royal Institution, Manchester.

1880. §Thomson, William J. Ghyllbank, St. Helens.

1906. ‡Thornely, Miss A. M. M. Oaklands, Langham-road, Bowdon, Cheshire.

1905 *Thornely, Miss L. R. Nunclose, Grassendale, Liverpool.

1898. *THORNTON, W. M., D.Sc., Professor of Electrical Engineering in the Armstrong College, Newcastle-on-Tyne.

1902. ‡Thornycroft, Sir John I., F.R.S., M.Inst.C.E. Eyot Villa, Chiswick Mall, W.

1903. ‡Thorp, Edward. 87 Southbank-road, Southport.

1881. ‡Thorp, Fielden. Blossom-street, York.

1881. *Thorp, Josiah. 37 Pleasant-street, New Brighton, Cheshire.

1898. §Thorp, Thomas. Moss Bank, Whitefield, Manchester.

1898. ‡THORPE, JOCELYN FIELD, Ph.D., F.R.S. Sheffield University.

1871. ‡THORPE, Sir T. E., C.B., Ph.D., LL.D., F.R.S., F.R.S.E., V.P.C.S. (Pres. B, 1890; Council, 1886-92.) 61 Ladbroke-grove, W.

1899. §THRELFALL, RICHARD, M.A., F.R.S. Oakhurst, Church-road, Edgbaston, Birmingham.

1896. §THRIFT, WILLIAM EDWARD, M.A. (Local Sec. 1908), Professor of Natural and Experimental Philosophy in the University of Dublin. 80 Grosvenor-square, Rathmines, Dublin.

1904. §Thurston, Edgar, C.I.E. Government Museum, Madras.

1907. ‡*Thwaites, R. E. 28 West-street, Leicester.*

1889. ‡Thys, Colonel Albert. 9 Rue Briderode, Brussels.

1873. *TIDDEMAN, R. H., M.A., F.G.S. 298 Woodstock-road, Oxford.

1905. ‡Tietz, Heinrich, B.A., Ph.D. South African College, Cape Town.

1874. ‡TILDEN, Sir WILLIAM A., D.Sc., F.R.S., F.C.S. (Pres. B, 1888; Council, 1898-1904), Professor of Chemistry in the Imperial College of Science, London. The Oaks, Northwood, Middlesex.

1899. ‡Tims, H. W. Marett, M.A., M.D., F.L.S. 8 Brookside, Cambridge.

Year of Election

1902. ‡Tipper, Charles J. R., B.Sc. 21 Greenside, Kendal.

1905. ‡Tippett, A. M., M.Inst.C.E. Cape Government Railways, Cape Town.

1911. §Tizard, Henry T. Magdalen College, Oxford.

1900. §Tocher, J. F., B.Sc., F.I.C. 5 Chapel-street, Peterhead, N.B.

1907. ‡Todd, Professor J. L. MacDonald College, Quebec, Canada

1889. §Toll, John M. 49 Newsham-drive, Liverpool.

1905. ‡Tonkin, Samuel. Rosebank, near Cape Town.

1875. ‡Torr, Charles Hawley. 35 Burlington-road, Sherwood, Nottingham.

1909. ‡Tory, H. M. Edmonton, Alberta, Canada.

1901. ‡Townsend, J. S., M.A., F.R.S., Professor of Physics in the University of Oxford. New College, Oxford.

1876. *TRAIL, J. W. H., M.A., M.D., F.R.S., F.L.S. (Pres. K, 1910), Regius Professor of Botany in the University of Aberdeen.

1883. ‡TRAILL, A., M.D., LL.D., Provost of Trinity College, Dublin, Ballylough, Bushmills, Ireland

1870. ‡TRAILL, WILLIAM A. Giant's Causeway Electric Tramway, Portrush, Ireland.

1868. ‡TRAQUAIR, RAMSAY H., M.D., LL.D., F.R.S., F.G.S. (Pres. D, 1900.) The Bush, Colinton, Midlothian.

1902. ‡Travers, Ernest J. Dunmurry, Co. Antrim.

1884. ‡Trechmann, Charles O., Ph.D., F.G.S. Hartlepool.

1908. §Treen, Henry M., B.Sc. Wicken, Soham, Cambridge.

1908. ‡Tremain, Miss Caroline P., B.A. Alexandra College, Dublin.

1910. §Tremearne, A. J. N. Tudor House, Blackheath Park, S.E.

1911. §Tremearne, Mrs. Tudor House, Blackheath Park, S.E.

1887. *Trench-Gascoigne, Mrs. F. R. Lotherton Hall, Parlington, Aberford, Leeds.

1903 ‡Trenchard, Hugh. The Firs, Clay Hill, Enfield.

1908. ‡Tresilian, R. S. Cumnor, Eglington-road, Dublin.

1905. ‡*TREVOR-BATTYE, A., M.A., F.L.S., F.R.G.S. Chilbolton, Stockbridge, R.S.O.*

1871. ‡TRIMEN, ROLAND, M.A., F.R.S., F.L.S., F.Z.S. Fawley, Onslow-crescent, Woking.

1902 ‡Tristram, Rev. J. F., M.A., B.Sc. 20 Chandos-road, Chorlton-cum-Hardy, Manchester.

1884. *Trotter, Alexander Pelham. 8 Richmond-terrace, Whitehall, S.W.

1887. *TROUTON, FREDERICK T., M.A., Sc.D., F.R.S. (Council, 1911–), Professor of Physics in University College, W.C.

1898. *Trow, Albert Howard, D.Sc., F.L.S., Professor of Botany in University College, Cardiff. 50 Clive-road, Penarth.

1885. *Tubby, A. H., F.R.C.S. 68 Harley-street, W.

1847. *Tuckett, Francis Fox. Frenchay, Bristol.

1905. §Turmeau, Charles. Claremont, Victoria Park, Wavertree, Liverpool.

1901. §Turnbull, Robert, B.Sc. Department of Agriculture and Technical Instruction, Dublin.

1893. ‡TURNER, DAWSON, M.D., F.R.S.E. 37 George-square, Edinburgh.

1894. *TURNER, H. H., M.A., D.Sc., F.R.S., F.R.A.S. (Pres. A, 1911), Professor of Astronomy in the University of Oxford. The Observatory, Oxford.

1905. ‡Turner, Rev. Thomas. St. Saviour's Vicarage, 50 Fitzroy-street, W.

1886. *TURNER, THOMAS, M.Sc., A.R.S.M., F.I.C., Professor of Metallurgy in the University of Birmingham. Springfields, Upland-road, Selly Hill, Birmingham.

Year of Election.

1863. *TURNER, Sir WILLIAM, K.C.B., LL.D., D.C.L., F.R.S., F.R.S.E. (PRESIDENT, 1900; Pres. H, 1889, 1897), Principal of the University of Edinburgh. 6 Eton-terrace, Edinburgh.
1910. §Turner, W. E. S. The University, Sheffield.
1890. *Turpin, G. S., M.A., D.Sc. High School, Nottingham.
1907. §TUTTON, A. E. H., M.A., D.Sc., F.R.S. (Council, 1908– .) Duart, Yelverton, South Devon.
1886. *Twigg, G. H. 6 & 7 Ludgate-hill, Birmingham.
1899. ‡Twisden, John R., M.A. 14 Gray's Inn-square, W.C.
1907. §Twyman, F. 75A Camden-road, N.W.
1865. ‡TYLOR, Sir EDWARD BURNETT, D.C.L., LL.D., F.R.S. (Pres. H, 1884; Council, 1896–1902) Linden, Wellington, Somerset.
1911. *TYNDALL, A. M., M.Sc. The University, Bristol.
1883. ‡Tyrer, Thomas, F.C.S. Stirling Chemical Works, Abbey-lane, Stratford, E.

1884. *Underhill, G. E., M.A. Magdalen College, Oxford.
1903. ‡Underwood, Captain J. C. 60 Scarisbrick New-road, Southport.
1908. §Unwin, Ernest Ewart, M.Sc. Bootham School, York.
1883. §Unwin, John. Eastcliffe Lodge, Southport.
1876. *UNWIN, W. C., F.R.S., Pres.Inst.C.E. (Pres. G, 1892; Council, 1892–99.) 7 Palace Gate-mansions, Kensington, W.
1909. ‡Urquhart, C. 239 Smith-street, Winnipeg, Canada.
1902. §Ussher, R. J. Cappagh House, Cappagh, Co. Waterford.
1880. ‡USSHER, W. A. E., F.G.S. 28 Jermyn-street, S.W.
1905. ‡Uttley, E. A., Electrical Inspector to the Rhodesian Government, Bulawayo.

1887. *Valentine, Miss Anne. The Elms, Hale, near Altrincham.
1908. ‡Valera, Edward de. University College, Blackrock, Dublin.
1905. ‡Van der Byl, J. A. P.O., Irene, Transvaal.
1865. *VARLEY, S. ALFRED. Arrow Works, Jackson-road, Holloway, N.
1907. §VARLEY, W. MANSERGH, M.A., D.Sc., Ph.D. Morningside, Eaton-crescent, Swansea.
1903. ‡Varwell, H. B. 2 Pennsylvania-park, Exeter.
1909. *Vassall, H., M.A. The Priory, Repton, Burton-on-Trent.
1907. §Vaughan, Arthur, B.A., D.Sc., F.G.S. 315 Woodstock-road, Oxford.
1895. ‡Vaughan, D. T. Gwynne, F.L.S., Professor of Botany in Queen's University, Belfast.
1905. ‡Vaughan, E. L. Eton College, Windsor.
1881. ‡VELEY, V. H., M.A., D.Sc., F.R.S. 8 Marlborough-place, St. John's Wood, N.W.
1883. *Verney, Lady. Claydon House, Winslow, Bucks.
1904. *Vernon, H. M., M.A., M.D. 22 Norham-road, Oxford.
1896. *Vernon, Thomas T. Shotwick Park, Chester.
1896. *Vernon, William. Shotwick Park, Chester.
1890. *Villamil, Lieut.-Colonel R. de, R.E. Carlisle Lodge, Rickmansworth.
1906. *VINCENT, J. H., M.A., D.Sc. L.C.C. Paddington Technical Institute, Saltram-crescent, W.
1899. *VINCENT, SWALE, M.D., D.Sc. (Local Sec. 1909), Professor of Physiology in the University of Manitoba, Winnipeg, Canada.
1883. *VINES, SYDNEY HOWARD, M.A., D.Sc., F.R.S., F.L.S. (Pres. K, 1900; Council, 1894–97), Professor of Botany in the University of Oxford. Headington Hill, Oxford.
1902. ‡Vinycomb, T. B. Sinn Fein, Shooters Hill, S.E.
1904. §Volterra, Professor Vito. Regia Università, Rome.

Year of Election

1904. §Wace, A. J. B. Pembroke College, Cambridge.
1902. ‡Waddell, Rev. C. H. The Vicarage, Saintfield.
1909. ‡Wadge, Herbert W., M.D. 754 Logan-avenue, Winnipeg, Canada.
1888. ‡Wadworth, H. A. Breinton Court, near Hereford.
1890. §**WAGER, HAROLD** W. T., F.R.S., F.L.S. (Pres. K, 1905.) Hendre, Horsforth-lane, Far Headingley, Leeds.
1900. ‡Wagstaff, C. J. L., B.A. Haberdashers' School, Cricklewood, N.W.
1902. ‡Wainwright, Joel. Finchwood, Marple Bridge, Stockport.
1906. ‡Wakefield, Charles. Heslington House, York.
1905. §Wakefield, Captain E. W. Stricklandgate House, Kendal.
1894. ‡**WALFORD, EDWIN** A., F.G.S. 21 West Bar, Banbury.
1882. *Walkden, Samuel, F.R.Met.S. The Cottage, Whitchurch, Tavistock.
1893. ‡Walker, Alfred O., F.L.S. Ulcombe-place, Maidstone, Kent.
1890. ‡Walker, A. Tannett. The Elms, Weetwood, Leeds.
1901. *Walker, Archibald, M.A., F.I.C. Newark Castle, Ayr, N.B.
1897. ***WALKER,** Sir **EDMUND**, C.V.O., D.C.L., F.G.S. (Local Sec. 1897.) Canadian Bank of Commerce, Toronto, Canada.
1904. §Walker, E. R. Nightingales, Adlington, Lancashire.
1911. *Walker, E. W. Ainley, M.A. University College, Oxford.
1891. ‡Walker, Frederick W. Tannett. Carr Manor, Meanwood, Leeds.
1905. ‡Walker, G. M. Lloyd's-buildings, Burg-street, Cape Town.
1894. ***WALKER,** G. T., M.A., D.Sc., F.R.S., F.R.A.S. Red Roof, Simla, India.
1897. ‡Walker, George Blake, M.Inst.C.E. Tankersley Grange, near Barnsley.
1906. ‡Walker, J. F. E. Gelson, B.A. 45 Bootham, York.
1894. ***WALKER, JAMES**, M.A. 30 Norham-gardens, Oxford.
1910. ***WALKER, JAMES**, D.Sc., F.R.S. (Pres. B, 1911), Professor of Chemistry in the University of Edinburgh. 5 Wester Coates-road, Edinburgh.
1906. §Walker, Dr. Jamieson. 37 Charnwood-street, Derby.
1909. ‡Walker, Lewie D. Lieberose, Monreith-road, Cathcart, Glasgow.
1907. ‡Walker, Philip F., F.R.G.S. 36 Prince's-gardens, S.W.
1909. §Walker, Mrs. R. 3 Riviera-terrace, Rushbrooke, Queenstown, Co. Cork.
1908. *Walker, Robert. Ormidale, Combe Down, Bath.
1888. ‡Walker, Sydney F. 1 Bloomfield-crescent, Bath.
1896. §Walker, Colonel William Hall, M.P. Gateacre, Liverpool.
1910. ‡Wall, G. P., F.G.S. 32 Collegiate-crescent, Sheffield.
1883. ‡Wall, Henry. 14 Park-road, Southport.
1911. §Wall, Thomas F., M.Sc., A.M.Inst.C.E. The University, Birmingham.
1863. ‡**WALLACE, ALFRED RUSSEL**, O.M., D.C.L., F.R.S., F.L.S., F.R.G.S. (Pres. D, 1876; Council, 1870–72.) Broadstone, Wimborne, Dorset.
1905. ‡Wallace, R. W. 2 Harcourt-buildings, Temple, E.C.
1901. ‡Wallace, William, M.A., M.D. 25 Newton-place, Glasgow.
1887. ***WALLER, AUGUSTUS** D., M.D., F.R.S. (Pres. I, 1907.) 32 Grove End-road, N.W.
1905. §Waller, Mrs. 32 Grove End-road, N.W.
1889. *Wallis, Arnold J., M.A., Corpus Christi College, Cambridge.
1895. ‡**WALLIS, E. WHITE**, F.S.S. Royal Sanitary Institute and Parkes Museum, 90 Buckingham Palace-road, S.W.
1894. ***WALMISLEY,** A. T., M.Inst.C.E. 9 Victoria-street, Westminster, S.W.
1891. §Walmsley, R. M., D.Sc. Northampton Institute, Clerkenwell, E.C.

Year of Election.

1908. ‡Walsh, John M. Pleona Park-avenue, Sidney-parade, Dublin.

1903. ‡Walsh, W. T. H. Kent Education Committee, Caxton House, Westminster, S.W.

1895. ‡WALSINGHAM, The Right Hon. Lord, LL.D., F.R.S. Merton Hall, Thetford.

1902. *Walter, Miss L. Edna. 38 Woodberry-grove, Finsbury Park, N.

1904. *Walters, William, jun. Albert House, Newmarket.

1887. ‡WARD, A. W., M.A., Litt.D., Master of Peterhouse, Cambridge.

1911. §Ward, A. W. Town Hall, Portsmouth.

1881. §Ward, George, F.C.S. Buckingham-terrace, Headingley, Leeds.

1874. ‡Ward, John, J.P., F.S.A. Beesfield, Farningham, Kent.

1905. ‡Warlow, Dr. G. P. 15 Hamilton-square, Birkenhead.

1884. *Warner, James D. 199 Baltic-street, Brooklyn, U.S.A.

1887. ‡WARREN, Lieut.-General Sir CHARLES, R.E., K.C.B., G.C.M.G., F.R.S., F.R.G.S. (Pres E, 1887.) Athenæum Club, S.W.

1875. *WATERHOUSE, Major-General J. Hurstmead, Eltham, Kent.

1905. ‡Watermeyer, F. S., Government Land Surveyor. P.O. Box 973, Pretoria, South Africa.

1904. ‡Waters, A. H., B.A. 48 Devonshire-road, Cambridge.

1900. ‡*Waterston, David, M.D., F.R.S.E. 23 Colinton-road, Edinburgh.*

1909. §Watkinson, Professor W. H. The University, Liverpool.

1884. ‡Watson, A. G., D.C.L. Uplands, Wadhurst, Sussex.

1901. *WATSON, ARNOLD THOMAS, F.L.S. Southwold, Tapton Crescent-road, Sheffield.

1886. *Watson, C. J. Alton Cottage, Botteville-road, Acock's Green, Birmingham.

1909. §WATSON, Colonel Sir C. M., K.C.M.G., C.B., R.E., M.A. 16 Wilton-crescent, S.W.

1906. ‡Watson, D. M. S. Windlehurst, Anson-road, Victoria Park, Manchester.

1909. ‡Watson, Ernest Ansley, B.Sc. Alton Cottage, Botteville-road, Acock's Green, Birmingham.

1892. ‡Watson, G., M.Inst.C.E. 5 Bigwood-road, Hampstead-way, N.W.

1885. ‡Watson, Deputy Surgeon-General G.A. Hendre, Overton Park, Cheltenham.

1906. *Watson, Henry Angus. 3 Museum-street, York.

1889. ‡Watson, John, F.I.C. P.O. Box 1026, Johannesburg, South Africa.

1905. ‡Watson, Dr. R. W. Ladysmith, Cape Colony.

1894. *WATSON, Professor W., D.Sc., F.R.S. 7 Upper Cheyne-row, S.W.

1879. *WATSON, WILLIAM HENRY, F.C.S., F.G.S. Braystones House, Beckermet, Cumberland.

1901. §Watt, Harry Anderson, M.P. Ardenslate House, Hunter's Quay, Argyllshire.

1910. *Watts, Miss Beatrix, M.A. Girton College, Cambridge.

1875. *WATTS, JOHN, B.A., D.Sc. Merton College, Oxford.

1873. *WATTS, W. MARSHALL, D.Sc. Shirley, Venner-road, Sydenham, S.E.

1883. *WATTS, W. W., M.A., M.Sc., F.R.S., F.G.S. (Pres. C, 1903; Council, 1902-09). Professor of Geology in the Imperial College of Science and Technology, London, S.W.

1870 ‡Watts, William, M.Inst.C.E., F.G.S. Kenmore, Wilmslow, Cheshire.

1911. §Waxweiler, Professor E. Solvay Institute, Brussels.

1905. ‡Way, E. J. Post Office, Benoni, Transvaal.

1905. ‡Way, W. A., M.A. The College, Graaf Reinet, South Africa.

1905. ‡Webb, Miss Dora. Gezina School, Pretoria.

1907. ‡Webb, Wilfred Mark. Odstock, Hanwell, W.

Year of Election.
1910. ‡Webster, Professor Arthur G. Worcester, Massachusetts, U.S.A.
1909. ‡Webster, William, M.D. 1252 Portage-avenue, Winnipeg, Canada.
1908. §Wedderburn, Ernest Maclagan, F.R.S.E. 7 Dean Park-crescent, Edinburgh.
1903. ‡Weekes, R. W., A.M.Inst.C.E. 65 Hayes-road, Bromley, Kent.
1890. *Weiss, F. Ernest, D.Sc., F.L.S. (Pres. K, 1911), Professor of Botany in the Victoria University, Manchester.
1905. ‡Welby, Miss F. A. Hamilton House, Hall-road, N.W.
1902. ‡Welch, R. J. 49 Lonsdale-street, Belfast.
1894. ‡Weld, Miss. 119 Iffley-road, Oxford.
1880. *Weldon, Mrs. Merton Lea, Oxford.
1908. ‡Welland, Rev. C. N. Wood Park, Kingstown, Co. Dublin.
1881. §Wellcome, Henry S. Snow Hill-buildings, E.C.
1911. §Welldon, Right Rev. J. E. C., D.D. (Pres. L, 1911.) The Deanery, Manchester.
1908. ‡Wellisch, E. M. 17 Park-street, Cambridge.
1881. ‡Wells, Rev. Edward, M.A. West Dean Rectory, Salisbury.
1911. *Welsford, Miss E. J. The University, Leeds.
1881. *Wenlock, The Right Hon. Lord, G.C.S.I., G.C.I.E., K.C.B., LL.D. Escrick Park, Yorkshire.
Wentworth, Frederick W. T. Vernon. Wentworth Castle, near Barnsley, Yorkshire.
1864. *Were, Anthony Berwick. The Limes, Walland's Park, Lewes.
1886. *Wertheimer, Julius, D.Sc., B.A., F.C.S., Principal of and Professor of Chemistry in the Merchant Venturers' Technical College, Bristol.
1910. §West, G. S., M.A., D.Sc., Professor of Botany in the University of Birmingham.
1900. §West, William, F.L.S. 26 Woodville-terrace, Horton-lane, Bradford.
1903. §Westaway, F. W. 1 Pemberley-crescent, Bedford.
1882. *Westlake, Ernest, F.G.S. Fordingbridge, Salisbury.
1900. ‡Wethey, E. R., M.A., F.R.G.S. 4 Cunliffe-villas, Manningham, Bradford.
1909. ‡Wheeler, A. O., F.R.G.S. The Alpine Club of Canada, Sidney, B.C., Canada.
1878. *Wheeler, W. H., M.Inst.C.E. 4 Hope-park, Bromley, Kent.
1888. §Whelen, John Leman. 23 Fairhazel-gardens, N.W.
1893. *Whetham, W. C. D., M.A., F.R.S. Upwater Lodge, Cambridge.
1888. *Whidborne, Miss Alice Maria. Charanté, Torquay.
1898. *Whipple, Robert S. Scientific Instrument Company, Cambridge.
1859. *Whitaker, William, B.A., F.R.S., F.G.S. (Pres. C, 1895; Council, 1890-96.) 3 Campden-road, Croydon.
1884. ‡Whitcher, Arthur Henry. Dominion Lands Office, Winnipeg, Canada.
1886. ‡Whitcombe, E. B. Borough Asylum, Winson Green, Birmingham.
1897. ‡Whitcombe, George. The Wotton Elms, Wotton, Gloucester.
1886. ‡White, A. Silva. Clarendon Lodge, St. John's-gardens, Holland Park, W.
1908. ‡White, Mrs. A. Silva. Clarendon Lodge, St. John's-gardens Holland Park, W.
1911. §White, Miss E. L., M.A. Day Training College, Portsmouth.
1904. ‡White, H. Lawrence, B.A. 33 Rossington-road, Sheffield.
1885. *White, J. Martin. Balruddery, Dundee.
1905. ‡White, Miss J. R. Huguenot College, Wellington, Cape Colony.
1910. *White, Mrs. Jessie, D.Sc., B.A. 23 Montague-street, W.C.
1897. *White, Sir W. H., K.C.B., F.R.S. (Pres. G, 1899, 1909; Council, 1897-1900, 1910- .) Cedarcroft, Putney Heath, S.W.

Year of
Election.

1877. *White, William. 20 Hillersdon-avenue, Church-road, Barnes, S.W.
1904. ‡WHITEHEAD, J. E. L., M.A. (Local Sec. 1904.) Guildhall, Cambridge.
1905. ‡Whiteley, Miss M. A., D.Sc. Imperial College of Science and Technology, S.W.
1893. ‡Whiteley, R. Lloyd, F.C.S., F.I.C. Municipal Science and Technical School, West Bromwich.
1907. *Whitley, E. Clovelly, Sefton Park, Liverpool.
1905. *Whitmee, H. B. P.O. Box 470, Durban, Natal.
1891. ‡Whitmell, Charles T., M.A., B.Sc. Invermay, Hyde Park, Leeds.
1897. ‡WHITTAKER, E. T., M.A., F.R.S., Royal Astronomer of Ireland and Andrews Professor of Astronomy in the University of Dublin. The Observatory, Dunsink, Co. Dublin.
1901. ‡Whitton, James. City Chambers, Glasgow.
1905. ‡Whyte, D. M. Simon's Town, Cape Colony.
1905. §Wibberley, C. The Lindens, Kew-road, Kew Gardens, Surrey.
1880. *WILBERFORCE, L. R., M.A., Professor of Physics in the University of Liverpool.
1887. *WILDE, HENRY, D.Sc., D.C.L., F.R.S. The Hurst, Alderley Edge, Cheshire.
1905. ‡Wiley, J. R. Kingsfold, Mill-street, Cape Town.
1910. §Wilkins, C. F. Lower Division, Eastern Jumna Canal, Delhi.
1905. ‡Wilkins, R. F. Thatched House Club, St. James's-street, S.W.
1904. §Wilkinson, Hon. Mrs. Dringhouses Manor, York.
1900. §Wilkinson, J. B. Holme-lane, Dudley Hill, Bradford.
1903. ‡Willett, John E. 3 Park-road, Southport.
1904. *Williams, Miss Antonia. 6 Sloane-gardens, S.W.
1861. *Williams, Charles Theodore, M.V.O., M.A., M.D. 2 Upper Brook-street, Grosvenor-square, W.
1905. §Williams, Gardner F. 2201 R-street, Washington, D.C., U.S.A.
1883. ‡Williams, Rev. H. Alban, M.A. Sheering Rectory, Harlow, Essex.
1861. *Williams, Harry Samuel, M.A., F.R.A.S. 6 Heathfield, Swansea.
1875. *Williams, Rev. Herbert Addams. Llangibby Rectory, near Newport, Monmouthshire.
1891. §Williams, J. A. B., M.Inst.C.E. Bloomfield, Branksome Park, Bournemouth.
1883. *Williams, Mrs. J. Davies. 5 Chepstow-mansions, Bayswater, W.
1888. *Williams, Miss Katharine T. Llandaff House, Pembroke-vale, Clifton, Bristol.
1901. *Williams, Miss Mary. 6 Sloane-gardens, S.W.
1891. ‡Williams, Morgan. 5 Park-place, Cardiff.
1883. ‡Williams, T. H. 27 Water-street, Liverpool.
1877. *WILLIAMS, W. CARLETON, F.C.S. Broomgrove, Goring-on-Thames.
1906. ‡Williams, W. F. Lobb. 32 Lowndes-street, S.W.
1857. ‡WILLIAMSON, BENJAMIN, M.A., D.C.L., F.R.S. Trinity College, Dublin.
1894. *Williamson, Mrs. Janora. 18 Rosebery-gardens, Crouch End, N.
1910. ‡Williamson, K. B., Central Provinces, India. Care of Messrs. Grindlay & Co., 54 Parliament-street, S.W.
1895. ‡WILLINK, W. (Local Sec. 1896.) 14 Castle-street, Liverpool.
1895. ‡Willis, John C., M.A., F.L.S., Director of the Royal Botanical Gardens, Peradeniya, Ceylon.
1896. ‡WILLISON, J. S. (Local Sec. 1897.) Toronto, Canada.
1859. *Wills, The Right Hon. Sir Alfred. Saxholm, Basset, Southampton.
1899. §Willson, George. Lendarac, Sedlescombe-road, St. Leonards-on-Sea.
1899. §Willson, Mrs. George. Lendarac, Sedlescombe-road, St. Leonards-on-Sea.

Year of Election.

1911. *Wilmott, A. J., B.A. Natural History Museum, S.W.
1911. §Wilsmore, Dr. N. T. M. 126 Walm-lane, Willesden Green, N.W.
1911. ‡Wilsmore, Mrs. 126 Walm-lane, Willesden Green, N. W.
1908. §Wilson, Miss. Grove House, Paddock, Huddersfield.
1901. ‡Wilson, A. Belvoir Park, Newtownbreda, Co. Down.
1886. ‡*Wilson, Alexander B. Holywood, Belfast.*
1878. ‡Wilson, Professor Alexander S., M.A., B.Sc. United Free Church Manse, North Queensferry.
1905. §Wilson, A. W. P.O. Box 24, Langlaagte, South Africa.
1907. §Wilson, A. W. Low Slack, Queen's-road, Kendal.
1903. ‡Wilson, C. T. R., M.A., F.R.S. Sidney Sussex College, Cambridge.
1894. *Wilson, Charles J., F.I.C., F.C.S. 14 Old Queen-street, Westminster, S.W.
1904. §Wilson, Charles John, F.R.G.S. Deanfield, Hawick, Scotland.
1904. §Wilson, David, M.D. Grove House, Paddock, Huddersfield.
1900. *Wilson, Duncan R. 44 Whitehall-court, S.W.
1895. ‡Wilson, Dr. Gregg. Queen's College, Belfast.
1901. ‡Wilson, Harold A., M.A., D.Sc., F.R.S., Professor of Physics in McGill University, Montreal, Canada.
1902. *Wilson, Harry, F.I.C. 32 Westwood-road, Southampton.
1879. ‡Wilson, Henry J., M.P. Osgathorpe Hills, Sheffield.
1910. §Wilson, J. S. 29 Denbigh-street, S.W.
1908. ‡Wilson, Professor James, M.A., B.Sc. Cluny, Orwell Park, Dublin.
1879. ‡Wilson, John Wycliffe. Easthill, East Bank-road, Sheffield.
1901. *Wilson, Joseph. Hillside, Avon-road, Walthamstow, N.E.
1908. *Wilson, Malcolm, D.Sc., F.L.S., Lecturer in Mycology and Bacteriology in the University of Edinburgh. Royal Botanic Gardens, Edinburgh.
1909. §Wilson, R. A. Hinton, Londonderry.
1903. ‡Wilson, Dr. R. Arderne. Saasveld House, Kloof-street, Cape Town.
1847. *Wilson, Rev. Sumner. Preston Candover Vicarage, Basingstoke.
1883. ‡Wilson, T. Rivers Lodge, Harpenden, Hertfordshire.
1892. ‡Wilson, T. Stacey, M.D. 27 Wheeley's-road, Edgbaston, Birmingham.
1861. ‡Wilson, Thomas Bright, 13 Ashcroft-villas, Cirencester.
1887. §Wilson, W. Battlehillock, Kildrummy, Mossat, Aberdeenshire.
1909. ‡Wilson, W. Murray. 29 South Drive, Harrogate.
1910. §Wilton, T. R., M.A., Assoc.M.Inst.C.E. 18 Westminster-chambers, Crosshall-street, Liverpool.
1907. §Wimperis, H. E., M.A. 16 Reynolds-close, Hampstead-way, N.W.
1910. ‡Winder, B. W. Ceylon House, Sheffield.
1886. ‡Windle, Sir Bertram C. A., M.A., M.D., D.Sc., F.R.S., President of University College, Cork.
1863. *Winwood, Rev. H. H., M.A., F.G.S. (Local Sec. 1864.) 11 Cavendish-crescent, Bath.
1905. §Wiseman, J. G., F.R.C.S., F.R.G.S. Stranraer, St. Peter's-road, St. Margaret's-on-Thames.
1875. ‡Wolfe-Barry, Sir John, K.C.B., F.R.S., M.Inst.C.E. (Pres. G, 1898; Council, 1899–1903, 1909–10.) Delahay House, 15 Chelsea Embankment, S.W.
1905. ‡Wood, A., jun. Emmanuel College, Cambridge.
1863. *Wood, Collingwood L. Freeland, Forgandenny, N.B.
1875. *Wood, George William Rayner. Singleton Lodge, Manchester.
1908. §Wood, Sir Henry J. 4 Elsworthy-road, N.W.
1878. ‡Wood, Sir H. Trueman, M.A. Royal Society of Arts, John-street, Adelphi, W.C.; and Prince Edward's-mansions, Bayswater, W.

Year of Election

1883. *Wood, J. H. 21 Westbourne-road, Birkdale, Lancashire.

1904. *WOOD, T. B., M.A., Professor of Agriculture in the University of Cambridge. Caius College, Cambridge.

1899. *Wood, W. Hoffman. Ben Rhydding, Yorkshire.

1901. *Wood, William James, F.S.A.(Scot.) 266 George-street, Glasgow.

1899. *Woodcock, Mrs. E. M. Care of Messrs. Stilwell & Harley, 4 St. James-street, Dover.

1896. *WOODHEAD, Professor G. SIMS, M.D. Pathological Laboratory, Cambridge.

1911. §Woodhead, T. W., Ph.D., F.L.S. Technical College, Huddersfield.

1888. * *Woodiwiss, Mrs. Alfred. 121 Castlenau, Barnes, S.W.*

1906. *Woodland, W. N. F. University College, Gower-street, W.C.

1904. §Woodrow, John. Berryknowe, Meikleriggs, Paisley.

1904. ‡Woods, Henry, M.A. Sedgwick Museum, Cambridge.

WOODS, SAMUEL. 1 Drapers'-gardens, Throgmorton-street, E.C.

1887. *WOODWARD, ARTHUR SMITH, LL.D., F.R.S., F.L.S., F.G.S. (Pres. C, 1909; Council, 1903–10), Keeper of the Department of Geology, British Museum (Natural History), Cromwell-road, S.W.

1869. *WOODWARD, C. J., B.Sc., F.G.S. The Lindens, St. Mary's-road, Harborne, Birmingham.

1886. ‡Woodward, Harry Page, F.G.S. 129 Beaufort-street, S.W.

1866. ‡WOODWARD, HENRY, LL.D., F.R.S., F.G.S. (Pres. C, 1887; Council, 1887–94.) 13 Arundel-gardens, Notting Hill, W.

1870. ‡WOODWARD, HORACE B., F.R.S., F.G.S. 85 Coombe-road, Croydon.

1894. *Woodward, John Harold. 8 Queen Anne's gate, Westminster, S.W.

1909. *Woodward, Robert S. Carnegie Institution, Washington, U.S.A.

1908. §WOOLACOTT, DAVID, D.Sc., F.G.S. 8 The Oaks West, Sunderland.

1890. *Woollcombe, Robert Lloyd, M.A., LL.D., F.I.Inst., F.R.C.Inst., F.R.G.S., F.R.E.S., F.S.S., M.R.I.A. 14 Waterloo-road, Dublin.

1883. *Woolley, George Stephen. Victoria Bridge, Manchester.

1908. ‡Worsdell, W. C. 2 Woodside, Bathford, Bath.

1863. *Worsley, Philip J. Rodney Lodge, Clifton, Bristol.

1901. ‡Worth, J. T. Oakenrod Mount, Rochdale.

1904. §WORTHINGTON, A. M., C.B., F.R.S. 1 The Paragon, Blackheath, S.E.

1908. *Worthington, James H., B.A., F.R.A.S. Wycombe Court, High Wycombe.

1906. ‡WRAGGE, R. H. VERNON. York.

1910. ‡Wrench, E. G. Park Lodge, Baslow, Derbyshire.

1896. ‡Wrench, Edward M., M.V.O., F.R.C.S. Park Lodge, Baslow, Derbyshire.

1905. ‡Wrentmore, G. G. Marva, Silwood-road, Rondebosch, Cape Colony.

1906. ‡Wright, Sir A. E., M.D., D.Sc., F.R.S. 6 Park-crescent, W.

1905. ‡Wright, Allan. Struan Villa, Gardens, Cape Town.

1883. *Wright, Rev. Arthur, D.D. Queens' College, Cambridge.

1909. ‡Wright, C. S., B.A. Caius College, Cambridge.

1905. * *Wright, FitzHerbert. The Hayes, Alfreton.*

1874. ‡Wright, Joseph, F.G.S. 4 Alfred-street, Belfast.

1884. ‡WRIGHT, Professor R. RAMSAY, M.A., B.Sc. University College, Toronto, Canada.

1904. ‡Wright, R. T. Goldieslie, Trumpington, Cambridge.

1911. §Wright, W. B., B.A., F.G.S. 14 Hume-street, Dublin.

1903. ‡Wright, William. The University, Birmingham.

Year of Election.

1871. ‡WRIGHTSON, Sir THOMAS, Bart., M.Inst.C.E., F.G.S. Neasham Hall, Darlington.
1902. ‡Wyatt, G. H. 1 Maurice-road, St. Andrew's Park, Bristol.
1901. ‡Wylie, Alexander. Kirkfield, Johnstone, N.B.
1902. ‡Wylie, John. 2 Mafeking-villas, Whitehead, Belfast.
1911. §Wyllie, W. L., R.A. Tower House, Tower-street, Portsmouth.
1899. ‡WYNNE, W. P., D.Sc., F.R.S., Professor of Chemistry in the University of Sheffield. 17 Taptonville-road, Sheffield.

1905. ‡Yallop, J. Allan. Alandale, London-road, Sea Point, Cape Colony.
1901. *Yapp, R. H., M.A., Professor of Botany in University College, Aberystwyth.
. *Yarborough, George Cook. Camp's Mount, Doncaster.
1894. *Yarrow, A. F. Campsie Dene, Blanefield, Stirlingshire.
1905. ‡Yerbury, Colonel. Army and Navy Club, Pall Mall, S.W.
1909. §Young, Professor A. H. Trinity College, Toronto, Canada.
1904. ‡Young, Alfred. Selwyn College, Cambridge.
1891. §Young, Alfred C., F.C.S. 17 Vicar's-hill, Lewisham, S.E.
1905. ‡Young, Professor Andrew, M.A., B.Sc. South African College, Cape Town.
1909. ‡Young, F. A. 615 Notre Dame-avenue, Winnipeg, Canada.
1894. *YOUNG, GEORGE, Ph.D. 46 Church-crescent, Church End, Finchley, N.
1909. §Young, Herbert, M.A., B.C.L., F.R.G.S. Arnprior, Ealing, W.
1901. *Young, John. 2 Montague-terrace, Kelvinside, Glasgow.
1905. ‡Young, Professor R. B. Transvaal Technical Institute, Johannesburg.
1885. ‡YOUNG, R. BRUCE, M.A., M.B. 8 Crown-gardens, Dowanhill, Glasgow.
1909. ‡Young, R. G. University of North Dakota, North Chautauqua, North Dakota, U.S.A.
1901. ‡Young, Robert M., B.A. Rathvarna, Belfast.
1883. *YOUNG, SYDNEY, D.Sc., F.R.S. (Pres. B, 1904), Professor of Chemistry in the University of Dublin. 12 Raglan-road, Dublin.
1887. ‡Young, Sydney. 29 Mark-lane, E.C.
1911. §Young, T. P. College of Agriculture, Holmes Chapel, Cheshire.
1907. *YOUNG, WILLIAM HENRY, M.A., Sc.D., F.R.S. La Nonette de la Forêt, Geneva, Switzerland.
1903. ‡Yoxall, Sir J. H., M.P. 67 Russell-square, W.C.

CORRESPONDING MEMBERS.

Year of Election.

1887. Professor Cleveland Abbe. Local Office, U.S.A. Weather Bureau, Washington, U.S.A.
1892. Professor Svante Arrhenius. The University, Stockholm. (Bergsgatan 18.)
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